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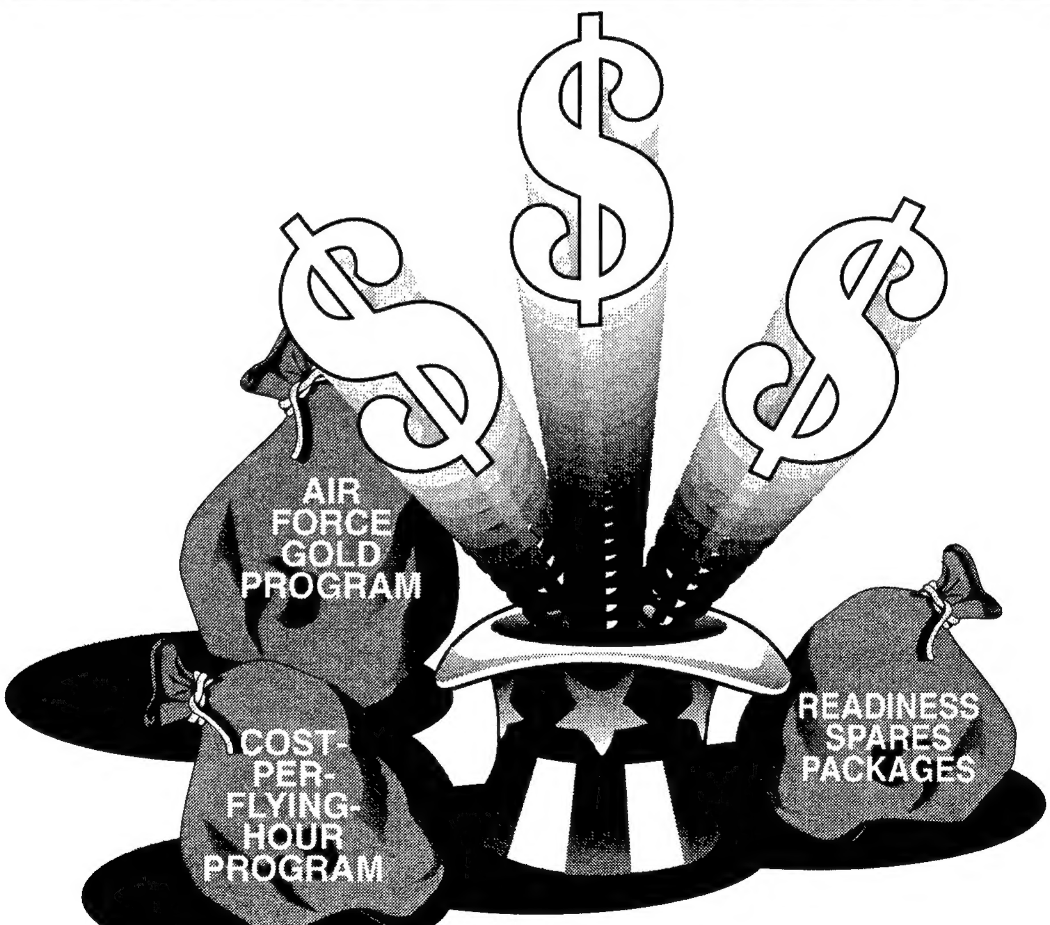

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CONTENTS

ARTICLES

DEPARTMENTS

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Unlikely Partners: Two-Level Maintenance and the Air Force Gold Program

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Introduction

Significant changes in Air Force logistics processes, beginning in the mid-eighties with Reliability and Maintainability (R&M) 2000, have resulted in several new logistics concepts, including Two-Level Maintenance (2LM) and the Air Force Gold Program.

Driven by economic, mobility, and manpower considerations, 2LM seeks to capitalize on R&M improvements and leverage them into significant manpower and budget reductions. In its simplest terms, 2LM consolidates a significant amount of base-level engine and avionics repair capability including manpower, tools, and test equipment at the five depots. This initiative has dramatically reduced the number of base-level maintenance positions and resulted in a significantly reduced mobility footprint.

The Air Force Gold Program's main objective is to optimize Air Force combat capability by reducing total Air Force materiel costs through the local repair of items or procurement of repair services. (4) Air Force Instruction (AFI) 21-123, *Air Force Gold Program*, provides guidance and procedures to increase base-level repair capability of aerospace parts and equipment. It focuses primarily on the base-level repair of XB3 and XF3 parts that were previously discarded—a good idea. On the down side though, this program has the potential to increase the specialized tools, equipment, and manpower required at base level.

Taken at face value, these two programs appear to be in conflict. This article examines 2LM and the Air Force Gold Program. A close examination confirms the conflict between the two, but also highlights the possibility for them to work as a partnership.

Shift from Three Levels to Two Levels of Maintenance

In the early 1980s, the Air Force was handicapped with a growing maintenance burden. More than one-third of Air Force manpower was devoted to aircraft maintenance. (9) R&M 2000 made significant progress, not only in designing and procuring new weapon systems, but in modifying current weapon systems to capitalize on technological advances. For example, the modernization of the E/FB-111 avionics package resulted in the mean time between failure (MTBF) of the planes' Doppler radar set expanding from 49 to several hundred hours. Its inertial navigation system MTBF went from 19 to several thousand hours. (2)

The C-17 was designed to take advantage of R&M improvements and design requirements. R&M requirements included a guaranteed maintenance man-hour-per-flying-hour and guaranteed percent of aircraft ready to fly at any given time. The modular engine design was a precursor to 2LM and was designed to result in a reduced work load and allow for a centralized repair facility. (11)

The F-22 was designed with a 2LM concept in mind. As a result of 2LM and other efforts to minimize its logistics tail, the F-22 will require only 45% of the personnel required by the F-15. It currently takes 17 C-141 loads to move a 24-aircraft squadron of F-15s; the F-22 will take 8. (5) The F-22 will also eliminate the requirement for avionics and jet engine intermediate repair shops by incorporating improved troubleshooting and repair capabilities in the design of the aircraft. (7)

Well before DESERT SHIELD/STORM, Military Airlift Command (now Air Mobility Command) logisticians, were driven by reduced manpower ceilings in Europe to examine the concept of Regional Repair Facilities for the European Theater. At the same time, they were exploring the possibility of consolidating stateside repair facilities. (12) As we entered the Gulf War, logisticians were not only pursing a 2LM concept for new weapons systems, but were examining it for possible use on current weapons systems.

As a result of 2LM and other efforts to minimize its logistics tail, the F-22 will require only 45% of the personnel required by the F-15.

In June 1992, the Secretary of the Air Force directed adoption of 2LM for every new weapon system and encouraged this concept, to the extent practical, for existing systems. (1) In December 1992, the program was approved by Defense Management Review Decision (DMRD) 983. (3) On 1 October 1993, the Air Force began the official implementation of 2LM for selected engines and avionics equipment. (6)

* JASDF stands for Japanese Air Self Defense Force

There is some risk of reduced readiness with 2LM. By eliminating intermediate-level maintenance, the overall maintenance effort becomes more dependent upon transportation and supply functions to get the right part to the right place at the right time. This new dependence has contributed to an initiative known as "Lean Logistics." Colonel Arthur Morrill, former Executive Officer, Deputy Chief of Staff for Logistics, Headquarters US Air Force, described Lean Logistics as:

> An interrelated series of logistics initiatives that promote capability, enhance our war fighting sustainability, shrink the logistics footprint, and reduce infrastructure. The goal is to enhance combat capability while reducing the annual operating costs of Air Force systems by adopting state-of-the-art business practices and streamlined processes and by reducing infrastructure throughout the Air Force Logistics Community. (10:14)

Lean Logistics is an umbrella concept describing the application and adaptation of successful public and private business practices to Air Force's logistics systems. 2LM is now a recognized cornerstone of the Air Force's Lean Logistics architecture. (10) The Lean Logistics initiative includes Repair and Return Packaging (R2P), Mail-Like Matter Movement (M3), Electronic Data Interchange (EDI), Just-In-Time practices (JIT), Industry Information Processor (I2P), and Cargo Movement Operations Systems (CMOS).

Gold Program Evolution and Impacts

While there exists a procedure to reduce the level of repair from depot to base level for high-cost parts, through the Air Force Technical Order (AFTO) Form 135, Source Maintenance and Recoverability (SMR) Code Change Request, XB3 and XF3 parts were routinely condemned and thrown away. Base-level maintenance personnel had neither the technical data nor financial incentives to support repair initiatives for these less expensive parts. It was easier to buy new parts.

In June 1990, a General Accounting Office study determined that numerous maintenance tasks could be done at the unit level and suggested the Air Force could save money by doing so. (15) In October of 1990, the 49th Fighter Wing (FW) at Holloman AFB, New Mexico, promoted an initiative that encouraged the repair of XB3 and XF3 parts. In one year they saved approximately $350,000 in operations and maintenance (O&M) costs. The success of the 49th FW generated immense popularity for the program. Commanders from other wings instituted their own programs to repair XB3 and XF3 parts. (14)

The XB3 and XF3 parts repair movement gained momentum. In 1991 alone, Luke AFB, Arizona, earned a cost avoidance of $1,000,000. A study completed by the Air Force Logistics Management Center (now Air Force Logistics Management Agency) in 1992 estimated a cost avoidance of approximately $760,000 per year for each F-16 base aggressively involved with XB3 and XF3 parts repair! (14) The Air Force formalized this process of increased unit-level repair with the publication of Air Force Instruction 21-123, *Air Force Gold Program*, dated 27 March 1995.

As previously stated, the main objective of the Air Force Gold Program is to optimize Air Force combat capability by reducing total Air Force materiel costs using local repair of parts or procurement of repair services. This is accomplished by units identifying parts, primarily XB3 and XF3, for local repair. Parts coded XD may also be considered under this program. (13)

The Gold Program places special attention on Circuit Card Repair (CCR) and Repair Initiatives Conferences (RICs). CCR encompasses troubleshooting, isolating, and repairing defective circuit cards using computer-based diagnostic equipment. The objective is to perform repairs on circuit cards previously coded throw away or not authorized for local repair. For example, back shop personnel at Randolph AFB, Texas, spent just $21.45 to repair an electrical component in a runway strobe light. This strobe light was thrown away in the past, requiring the purchase of the entire assembly at a cost of $1,000 per light. Although Randolph AFB used only five strobe lights a year, they saved $978.55 in cost avoidance per light. At Moody AFB, Georgia, technicians realized a cost avoidance through CCR repairs of $200,000 in a six-month period in 1992. (15)

In 1991 alone, Luke AFB earned a cost avoidance of $1,000,000. A study completed by the Air Force Logistics Management Center in 1992 estimated a cost avoidance of approximately $760,000 per year for each F-16 base aggressively involved with XB3 and XF3 parts repair!

RICs provide a senior-level forum where repair initiative originators and depot approvers can break communication "gridlocks," provide cross-tell opportunities, explore new technology, demonstrate repair processes, and conduct on-site repair shop visits. RICs have also proven very effective in obtaining approval for base-level repairs. Job fairs provide base-level personnel the chance to show depot engineers how they can repair parts previously condemned and thrown away. At these fairs, many repairs are authorized on-the-spot and dozens of parts coded XB3 have been recoded XF3 to indicate they can be repaired at the unit level. For example, maintenance personnel at Travis AFB, California, found a tool to reflange aircraft bleed air ducts. The current Air Force tool has 50 pieces and fills two boxes. The new tool, used in commercial industry, comes in one piece and is adjustable to the size of the duct. Maintenance personnel demonstrated this tool and showed how it could repair five to six ducts in the same time it took to assemble the current tool! (8) The initiative was approved by depot engineers on-the-spot.

While Gold Programs provide savings at the unit level, caution is needed. Unit-level actions may result in an increased requirement for test equipment and repair parts with an associated

increase in the mobility footprint. The problem is created when one unit's mobility requirements, as a result of Gold Program initiatives, becomes significantly different from another's. Since the Gold Program is managed at the major command (MAJCOM) level, no current Air Force-level oversight exists to avoid this possibility.

Comparing the Two Programs

Having looked at each program separately, let us now compare the two programs, focusing on repair capability, mobility, supply, and money. Both 2LM and the Gold Program deal with repair capability and base self-sufficiency issues. 2LM consolidates tools, test equipment, and specialized training at a location other than a unit's home base, reducing their intermediate repair capability for avionics and engine parts. The Gold Program improves base-level repair capability by encouraging units to repair items they previously discarded or returned to depots for repair. In other words, one program seeks to consolidate specialized repair actions while the other encourages broader use of common maintenance practices at individual units.

Two-level maintenance resulted in a significant reduction in the mobility footprint associated with aircraft maintenance units. Through the Gold Program, many units purchased additional tools and test equipment to repair XB and XF parts. Many of these assets will be brought in-theater during a crisis to enhance maintenance repair capability. At present, this additional lift challenge appears to be limited to those relatively few bases with established Gold Programs. However, as the Gold Program matures and additional equipment is brought on-line, the potential for an increase in the mobility footprint becomes real.

Equally troubling is the supply stockage aspect of differing levels of repair capability at individual units. As units repair items, depots will (and should) reduce on-hand supplies. However, when units deploy and revert to reliance on the supply system for the once locally-repaired part, the depots may not have that part in stock since the demand for it has been very low due to unit repair. If the lack of the part caused an aircraft to be not mission capable, the impact is magnified and the situation becomes unacceptable.

While money and funding levels have always been important, as available funds have shrunk, the emphasis to "do more with less" has pushed organizations to seek more cost effective ways of doing business. Under Three-Level Maintenance (3LM), base-level units shipped items to the depot for repair **at no cost to the unit**. 2LM was implemented in conjunction with the Depot Level Reparables (DLR) process. When DLR was implemented, units had to pay for each item they received from the depot out of their DLR budget. The DLR cost included both the repair cost and a surcharge that covered transportation and depot overhead costs. (8)

As logisticians were mastering the DLR budget process, they also saw their base-level O&M budgets shrink. Combining this with an increased emphasis on cost accounting, they began to look for ways to reduce base-level O&M costs. The Gold Program fit this need nicely. Units were encouraged to save money by repairing items locally. With their previous intermediate-level repair items now being sent to the depot, the extensive number of XB and XF items previously ignored presented a wide variety of opportunities to save money. Money saved on the repair or replacement of these items has a direct bottom line impact on the unit's budget.

Conclusion

Having examined the two programs, the following conclusions can be drawn. From a purely philosophical perspective, 2LM and the Air Force Gold program are in conflict. While 2LM takes tasks previously accomplished at the unit level and transfers them to the depot, the Gold Program encourages units to identify additional tasks that can be performed at unit level. As 2LM consolidates repairs at the depot, the Gold Program attempts to spread repairs across units and local contractors.

If the philosophical arguments are put aside and the two programs are compared in practical terms, there is little actual conflict and the basis for a partnership emerges. 2LM focuses primarily on engines and avionics, while the Gold Program has become synonymous with XB3 and XF3 parts (with the notable exception of repairing faulty circuit cards internal to avionics "black boxes"). From this perspective, the two programs are essentially independent of each other. While there are instances where units recode an item from depot to unit repair, they are not the norm. The most likely scenario under the Gold Program involves a unit developing base-level repair capability for "throw away" parts.

The real issue is how to improve the programs so they complement each other and benefit the Air Force as a whole. While the objective of both programs is to increase maintenance efficiency, the processes they use to accomplish this objective are diametrically opposed. 2LM centralizes repair activities to take advantage of economies of scale and standardization, while the Gold Program decentralizes repair activities to tap into the ingenuity and unique opportunities at each unit.

If the philosophical arguments are put aside and the two programs are compared in practical terms, there is little actual conflict and the basis for a partnership emerges.

The Air Force Gold Program and 2LM are part of the Air Force way of doing business today. Fiscal constraints, continued downsizing, and the need to reduce our mobility footprint require the Air Force to seek innovative ways to save both money and manpower.

The Air Force plans to rewrite AFI 21-123 later this year. The Gold Program has matured to the point that it deserves a second look, and the program's course corrected to keep it on track with Air Force-wide goals and objectives. Incorporating the following changes will significantly improve the program while ensuring

it does not result in negating the gains in mobility footprint reductions achieved under 2LM:

(1) Gold Programs should be established at bases that currently do not have one. Increased formal cross flow of information between similar units (across MAJCOMs) needs to be established to help standardize repair capabilities. The differing levels of contractor support available to continental United States (CONUS) and overseas locations needs to be addressed.

(2) The need for a reduced mobility footprint requires Gold Program emphasis. Headquarters Air Force needs to monitor the Gold Program with an eye toward maintaining standardized mobility requirements and avoiding the development of differing levels of in-house repair capability in similar units. This standardization is critical for deploying weapon systems to ensure each unit has approximately the same capability to repair parts. Failure to address this area can result in an unacceptable increased airlift requirement and larger mobility footprint, along with differing maintenance capabilities at forward locations.

(3) The implications for supply support when units deploy need to be researched more fully to determine if the perceived stockage problem is large enough to warrant action. In addition, the base-level supply system needs to become more fully integrated into the Gold Program. Gold Program personnel currently receive, store, and issue parts from their own "warehouses." These personnel are typically maintenance-trained troops who have limited knowledge of supply policies and requirements. Setting up a second de facto supply system on each base is not cost effective. Supply must work within its established systems to perform the Gold Program operations normally associated with supply including receiving, storing, issuing, and researching. This includes modifying existing supply procedures to allow credit for assets repaired under the Gold Program.

(4) Air Education and Training Command's (AETC's) concept of establishing a separate account for their Gold Way* savings is an outstanding idea. It provides a clear tracking device that requires units to transfer funds from savings into the account and shows how those savings were spent. This concept needs to be incorporated into the Air Force Gold Program. This will provide control, visibility, standardized accounting procedures, and accurate savings figures.

Incorporating these changes into AFI 21-123 will add validity and credibility to the Gold Program and strengthen an unlikely partnership that has the potential to save the Air Force millions of dollars a year.

* AETC Instruction 21-111, *Gold Way*, encourages units to expand local repair and contracting procedures to increase base-level self sufficiency while saving money.

References

1. Air Force Audit Agency. "Air Force Two Level Maintenance Planning," Project No. 93062003, Washington DC: AFAA, 27 Apr 94.
2. Canan, James W. "Staying Power," *AIR FORCE Magazine*, Vol 74, No. 7 (Jul 91), pp. 42-27.
3. Defense Management Review Decision No. 983. *Air Force FY 1994 Defense Management Report (DMR) Proposals*, 10 Dec 92.
4. Department of the Air Force. AFI 21-123, *Air Force Gold Program*, Washington DC: U.S. Government Printing Office, 27 Mar 95.
5. Department of the Air Force. *Air Force Issues Book 1992*, Washington DC: U.S. Government Printing Office, 1992.
6. Grier, Peter. "Behind the High Readiness Rates," *AIR FORCE Magazine*, Vol 77, No. 3 (Mar 94), p. 24.
7. Lee, Ronald, Lt Col, USAF. *Two Level Maintenance The Way of The Future*, AWC Research Report, Maxwell AFB AL, 1994.
8. Lewandowski, Chip, Maj, USAF. "Stock Funding of Depot Level Repairables," *Air Force Journal of Logistics*, Vol XV, No. 3 (Summer 91), pp. 1-13.
9. McDonald, Charles C., Gen, USAF. "Whatever Happened to R&M? Nothing, It's Alive and Working," *Air Force Journal of Logistics*, Vol XV, No. 4 (Fall 91), pp. 22-23.
10. Morrill, Arthur B. III, Col, USAF. "Lean Logistics: Its Time Has Come!," *Program Manager*, Vol 24, No. 1 (Jan-Feb 95).
11. Pauly, J. D., Capt, USAF. "C-17 R&M," *Airlift*, Vol 9, No.1 (Spring 87), pp. 4-7.
12. Perry, Gary, Capt, USAF. "New Approach: MAC Tests, Implements Maintenance Concepts (Part 2)," *Airlift*, Vol 13, No. 3 (Fall 91), pp. 14-16.
13. Quinones, William P., Capt, USAF. "Circuit Card Repair and Base Self-Sufficiency," *Air Force Journal of Logistics*, Volume XVII, Nos. 1&2 (Winter-Spring 93), p. 16.
14. Quinones, William P., Capt, USAF, et al. "XB3 and XF3 Repair Study." Project No. LM912092, Gunter AFB, AL: Air Force Logistics Management Center, 3 Feb 92.
15. Tanzi, Debra K., and Rick Burnham, SSgt, USAF. "Fast Fix," *AIR FORCE Magazine*, Jun 92, pp. 78-81.

The authors are logistics officers and were attending Air Command and Staff College at Maxwell AFB, Alabama, at the time this article was written.

Most Significant Article Award of 1995

The Editorial Advisory Board has selected "A New Look at Wholesale Logistics" by Wing Commander David J. Foster, RAF, as the most significant article published in the *Air Force Journal of Logistics* during 1995.

Cost-Per-Flying-Hour Program: A Foundation For Wing Cost Reduction

Captain Gary Wiley, Jr., USAF
Master Sergeant Thaddeus J. Dick, USAF

Introduction

Since the Air Force decided to include all aircraft commodities within a centralized stock fund, aircraft maintainers and operators continue to struggle with the integration of flying operations and financial management of flying assets. However, the financial management of flying operations is much easier than most realize. Although the program can be very complex, reduced to its very basic levels, calculating cost-per-flying-hour (CPFH) is a matter of simple mathematics. The way the results are used and who these results are communicated to, contribute most to the execution of the CPFH program. This article will highlight a successful CPFH program and why it is important in the execution of wing flying operations.

Review of Flying Hour Commodities

A brief review of the flying hour program follows. Three variables, or commodities, make up the flying hour program: depot level reparables (DLRs), consumables, and aviation fuel (AVPOL). All three are used in direct support of aircraft flying operations.

DLRs are budget code 8 items with an expendability, repairability, recoverability code (ERRC) of XD1 or XD2 and element of expense investment code (EEIC) of 644 for flying hour organizations and 645 for nonflying hour organizations. DLRs are used to repair aircraft, pods, engines, support equipment, etc. DLR examples are aircraft line replaceable units (LRUs) for major weapon subsystems (avionics, fuels, hydraulics, etc.), shop replaceable units (SRUs) (circuit card assemblies for electronic countermeasure [ECM] and Low Altitude Navigation and Targeting Infrared for Night [LANTIRN] pods, etc.), and test replaceable units (TRUs) for back shop support equipment. These high-priced items contribute most to the CPFH. (1)

Consumables are budget code 1 and 9 items with an ERRC of XB3 and XF3 and an EEIC of 605 and 609. System support division, part of the Air Force Stock Fund managed by the Air Force, manages budget code 1, EEIC 605 items. General support division, also part of the Air Force Stock Fund managed by the Defense Logistics Agency, manages budget code 9, EEIC 609 items. These "throwaway" items, benchstock, local purchase (LP) store items, disposable aircraft parts (panels, wiring harnesses, light bulbs, etc.), individual equipment (IE), consolidated tool kits (CTKs), test equipment parts, and one-time purchases are used to facilitate routine repairs and everyday business.

Aviation fuel, EEIC 699, is the fuel used to power aircraft. Figure 1 illustrates the combination of the three variables' costs

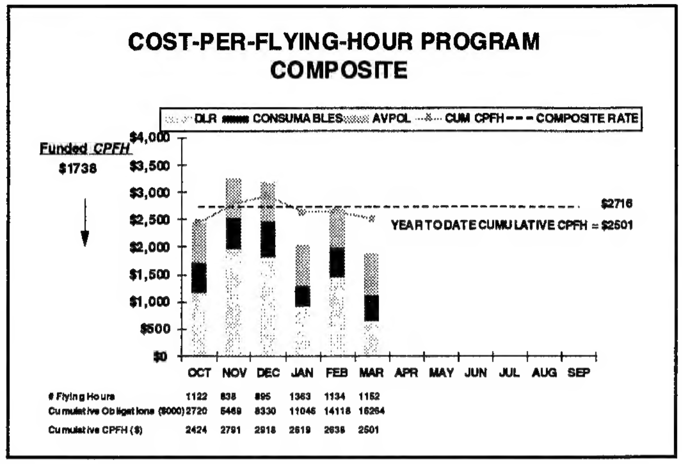

Figure 1. Cost-Per-Flying-Hour Program Composite

to determine total CPFH costs.

Determining commodity and total CPFH requires very little effort and is a matter of simple mathematics. Each wing is allocated a specific number of flying hours to execute in a fiscal year. Every month the wing will fly a portion of those hours. Simply divide the commodity costs by the number of flying hours to determine commodity CPFH. Example: DLR CPFH = $1,634,823.88 (monthly DLR costs) divided by 1,157.3 (monthly flying hours) = DLR CPFH of $1,412.13. This represents the DLR cost for every flying hour. Do the same for total consumables (budget code 1 and 9), and AVPOL, and add the three totals to determine total wing CPFH.

Reducing the CPFH to its absolute basic level defines the overall CPFH. This is nothing more than the per-hour cost to fly aircraft. Offsetting and reducing costs to gain program efficiencies are important when executing the CPFH process; however, establishment of a CPFH program office must be the first step in a successful and efficient CPFH program.

Establishing a CPFH Program

Determining wing CPFH is not enough. A full-time program office dedicated to monitoring and reporting wing flying hour expenditures is vital to success. This article will focus on the successful program built from the ground up at the 31st Fighter Wing, Aviano Air Base, Italy. This program will be used as the starting point to build and execute a wing CPFH program. Each wing has its own unique requirements, and its CPFH program must be tailored to meet wing needs. Important though, is the need for a workable CPFH program. Simplify the program without duplicating the efforts of other organizations within the wing. The primary goal is to monitor and report wing CPFH with the hope of reducing flying hour costs. Significant other

duties and responsibilities occur during program evolution; however, maintain focus on the primary goal. Justification and validation of every flying-hour expense incurred by the wing is absolutely essential. The ability to account for and portray all cost is directly proportional to the funding the major command (MAJCOM) provides the wing.

The first step is to engage the necessary personnel to provide accurate and timely information regarding costs associated with flying wing aircraft. Program complexity and personnel's knowledge will determine the number of personnel in the office. At Aviano, four unit project fund management records (PFMRs) are monitored and the program has three analysts and a program manager to report extracted data. Optimally, recommend personnel with strong backgrounds in supply, maintenance, and finance. However, team players with good analytical skills, a strong sense of achievement, and the ability to learn quickly will benefit the program immensely. Much time is dedicated to finding and reporting accurate information; therefore, good communication skills (writing and speaking) are desirable. Good communication skills also lend credibility to the program.

Current Air Force and MAJCOM instructions align the Depot Level Reparables program under the Logistics Group (LG). (4) An Aviano logistics operating instruction includes all flying-hour commodities into a CPFH office as part of the LG staff. Since most coordinating agencies are within the LG, alignment of the CPFH program office under the LG is logical. A logistics operating instruction establishes program duties and responsibilities and lends the program credibility. Program guidance provides stability and purpose.

Managing, Monitoring, and Reporting CPFH

Again, the primary job is to monitor and report unit flying-hour costs, and the best method is through the extraction of daily costs from each individual unit's Project Fund Management Report/Organization Cost Center Record Reconciliation (PFMR/OCCR Reconciliation), commonly known as the D11. This supply product is a daily listing printed for the organization resource advisor or cost center manager. Aviano's CPFH office receives the D11 information via electronic mail. The D11 (Figure 2) lists all the organization cost center records (OCCRs) under each unit's project fund management record (PFMR). It is used to track all DLR and consumables costs and will report all information required regarding how much and what work center is spending wing flying-hour funds.

Numerous other resources exist throughout the wing to aid in monitoring and reporting flying-hour costs. Developing rapport with maintenance shops and the flight line, the local analysis section, engine management branch, various organizations throughout base supply including fuels management section, unit resource advisors and cost center managers, wing financial management, maintenance officers, commanders, outside sources, etc., is almost as important as the monitoring and reporting of wing costs. Answers to taskings received will (most probably) be provided by other organizations within the wing. Cultivate and utilize these sources to accurately report the expenditure activity of the wing. Leave the analysis to the analysts in the Operations Support Squadron, but use their analysis to expand on CPFH increases and decreases. Accurate CPFH reporting is a team effort involving many different organizations who have a stake in the process. Work with all coordinating agencies to efficiently reduce flying-hour costs.

Develop wing target levels for the various commodities using previous fiscal year performance as a baseline to build the current fiscal year program. Factor in projected weapon systems costs, commodity price changes, flying hours, deployment factors, etc. AFI 65-503, *USAF Cost and Planning Factors,* gives recommended costs for each commodity factor by aircraft mission design series (MDS). The debate still rages about how these cost factors interface with Air Force Cost Analysis Improvement Group (AFCAIG) developed rates. At Aviano, these factors are used as baselines in the development of wing targets; recommend utilizing these factors just the same.

Developing and using visual information and electronic mediums are also important. Divide DLRs and consumables into distinct sections to provide visual status of wing performance. Color visuals are high impact and "paint" a picture of the wing spending performance. Unique wing requirements define the information presented. The slides shown in Figures 3 through 7

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513 TOTAL THIS SHOP CODE FOR S/D 01			**********************					$1,957.30		$.00			

Figure 2. Project Fund Management Report/Organization Cost Center Record Reconciliation (PFMR/OCCR Reconciliation)

are effective in illustrating wing and unit spending performance. Automation also makes the job much easier. The electronic spreadsheet in Figure 8 (see page 8) portrays large quantities of information at a glance. Develop and use these formats to portray wing spending performance. Today's fast-paced, high technology Air Force also demands usage of electronic mail as a method of communication and CPFH information sharing. Developing and utilizing other CPFH contacts inside and outside the MAJCOM contributes significantly to program success.

Accurate and timely reporting of wing CPFH information is absolutely essential in providing necessary funding levels from the MAJCOM to support wing flying hour operations. Clear, concise, and accurate information validates program expenditures and rewards the effort expended in execution of the CPFH program. The MAJCOM is more willing to provide funding support for well-managed programs than it is for programs having difficulty validating their costs.

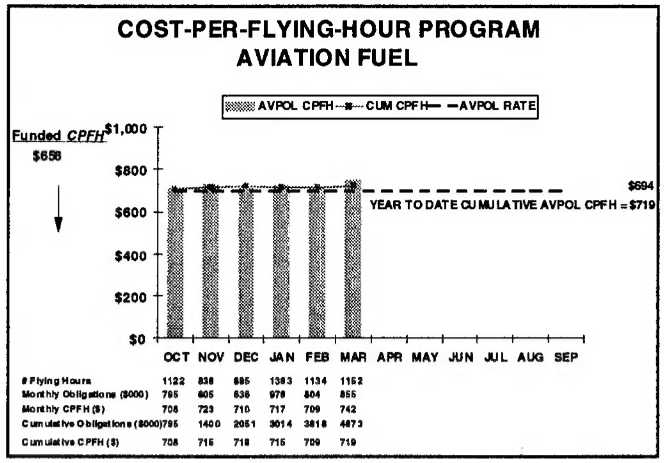

Figure 3. Aviation Fuel

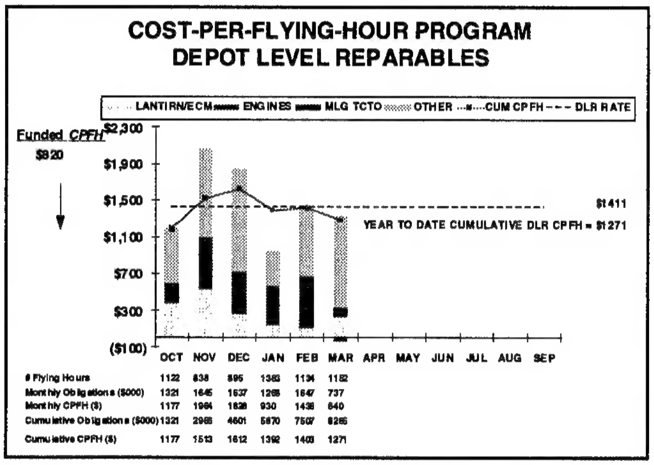

Figure 4. Depot Level Reparables

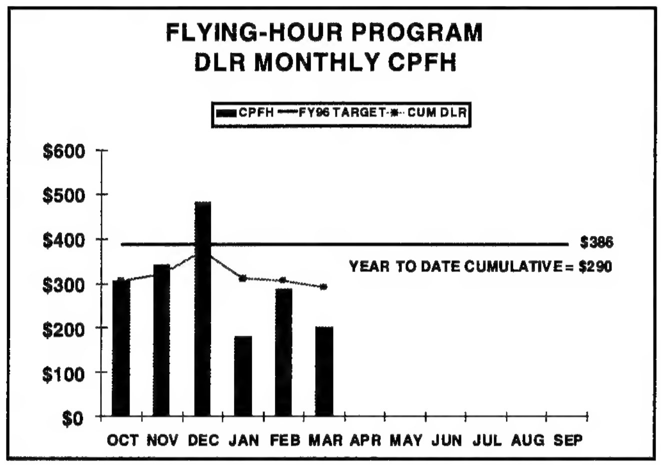

Figure 5. Depot Level Reparables Monthly Cost-Per-Flying-Hour

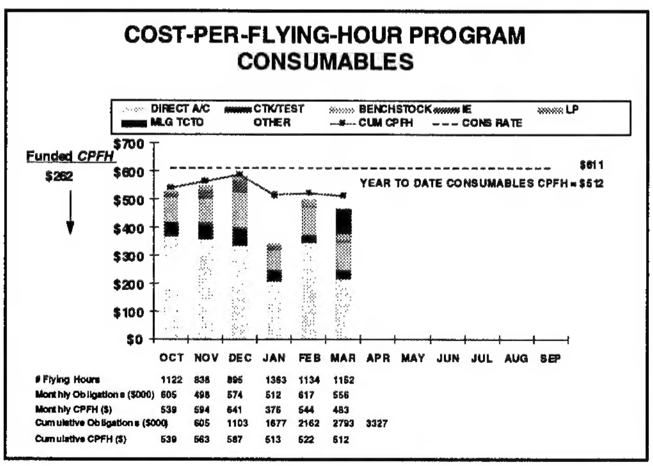

Figure 6. Consumables

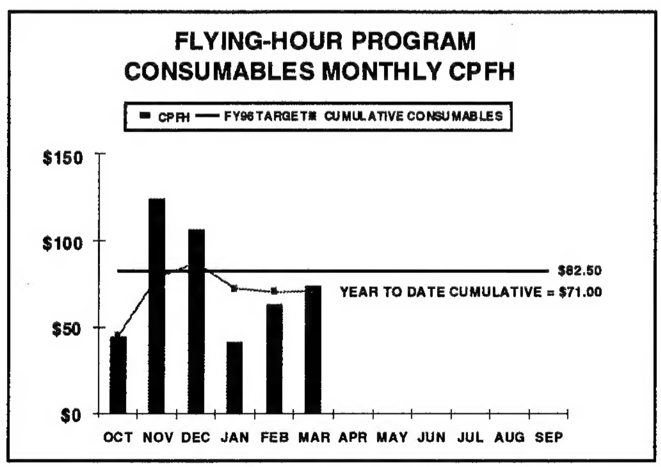

Figure 7. Consumables Monthly Cost-Per-Flying-Hour

LEGEND

AVPOL - AVIATION FUEL
CTK/TEST - CONSOLIDATED TOOL KITS/TEST EQUIPMENT
CONS - CONSUMABLES
CPFH - COST-PER-FLYING-HOUR
CUM - CUMULATIVE
DLR - DEPOT LEVEL REPARABLES
DIRECT A/C - DIRECT AIRCRAFT
IE - INDIVIDUAL EQUIPMENT
LP - LOCAL PURCHASE
LANTIRN/ECM - LOW ALTITUDE NAVIGATION AND TARGETING INFRARED FOR NIGHT/ ELECTRONIC COUNTER MEASURES
MLG TCTO - MAIN LANDING GEAR TIME COMPLIANCE TECHNICAL ORDER

31 FW Cost-Per-Flying-Hour (CPFH) Cumulative Summary

CPFH RATES

	DLR	CONSUMABLES	AVPOL	TOTAL CPFH
USAFE Funded Rates	$820	$262	$656	$1,738
CPFH FY96 Projections	$1,411	$611	$694	$2,716
Current CPFH Rates	$640	$482	$742	$1,865
Cumulative CPFH Rates	$1,271	$512	$719	$2,501

MONTHLY FLYING HOURS

Month - MARCH	Flying Hours	1,151.70

MONTHLY CPFH TOTALS

UNIT	510 FS	555 FS	31 MS	RAMSTEIN	Log/Ops Staff	WING TOTALS
Consumables Cost	85,342.15	77,472.95	239,015.98	42,699.01	111,087.23	$ 555,617.32
Satellite Accounts						$ -
Total Consumables	85,342.15	77,472.95	239,015.98	42,699.01	111,087.23	$ 555,617.32
DLR Cost	231,729.54	270,572.41	284,613.03	(49,825.01)	0.00	$ 737,089.97
Satellite Accounts			(349.50)			$ (349.50)
Total DLR	231,729.54	270,572.41	284,263.53	(49,825.01)	-	$ 736,740.47
Consumables CPFH	74.10	67.27	207.53	37.07	96.46	$ 482.43
DLR CPFH	201.21	234.93	246.82	-43.26	0.00	$ 639.70
Gallons	1,125,114					1,125,114
Cost	855,086.64					$ 855,086.64
AVPOL CPFH	742.46					$ 742.46
TOTAL EXPENDITURES						$ 2,147,793.93
TOTAL MONTHLY CPFH						$ 1,864.59

CUMULATIVE DLR PROGRAM

UNIT	510 FS	555 FS	31 MS	RAMSTEIN	Staff/Off Station	WING TOTALS
Previous Cumulative DLR Cost	1,653,840.05	1,608,614.74	1,902,928.85	2,362,637.08		$ 7,528,020.72
Total DLR	1,885,569.59	1,879,187.15	2,187,192.38	2,312,812.07		$ 8,264,761.19
DLR CPFH	289.96	288.98	336.34	355.66		$ 1,270.93

CUMULATIVE CONSUMABLES PROGRAM

UNIT	510 FS	555 FS	31 MS	RAMSTEIN	STAFF	WING TOTALS
Previous Cumulative Consumables Costs	375,751.48	425,220.89	1,088,325.06	834,249.13	47,408.99	$ 2,770,955.55
Local Purchase	19,481.66	21,861.47	46,581.50		17,304.15	$ 105,228.78
Individual Equipment	34,647.45	53,478.63	49,114.72	36.00		$ 137,276.80
Benchstock	77,200.22	122,885.88	339,949.00	43,626.61		$ 583,661.71
CTK/Test	42,458.86	122,655.84	128,820.41			$ 293,935.11
Direct Aircraft	245,384.05	190,240.39	674,074.95	802,261.87	10,324.85	$ 1,922,286.11
One Time Buys	132.38	3,893.44	49,059.41		18,469.83	$ 71,555.06
TCTO/Time Change	9,960.74	(12,321.81)	11,647.75	28,854.36	112,397.39	$ 150,538.43
Mobility/Hazardous Waste			14,605.63			$ 14,605.63
Aircraft Paint				2,169.30		$ 2,169.30
Off Station Consumables	31,828.27		13,487.67			$ 45,315.94
SQUADRON TOTALS	461,093.63	502,693.84	1,327,341.04	876,948.14	158,496.22	$ 3,326,572.87
CONSUMABLES CPFH	70.91	77.30	204.12	134.85	24.37	$ 511.55

CUMULATIVE AVPOL PROGRAM

		WING TOTALS
Previous Cumulative Gallons	5,023,604	
Previous Cumulative Cost	3,817,939.04	
Cumulative Gallons	6,148,718	6,148,718
Cumulative Cost	4,673,025.68	$ 4,673,025.68
AVPOL CPFH	718.61	$ 718.61

CUMULATIVE WING CPFH PROGRAM

Previous Cumulative Hour Total	5,351.20		
Cumulative Flying Hours	6,502.90		
		DLR CPFH	$ 1,270.93
DLR Total	$ 8,264,761.19	**Consumables CPFH**	$ 511.55
Consumables Total	$ 3,326,572.87	**AVPOL CPFH**	$ 718.61
AVPOL Total	$ 4,673,025.68		
Cumulative Expenditures	$ 16,264,359.74	**Cumulative CPFH**	$ 2,501.09

Figure 8. Cost-Per-Flying-Hour (CPFH) Cumulative Summary

Keys To a Successful CPFH Program

Program success is contingent upon many different variables. Training is absolutely the single most important factor in successful program execution. At Aviano, CPFH block training has been incorporated into maintenance training for operators, flight commander briefings, and dedicated crew chief training. A published wing CPFH guide is currently being used as a model for command guidance and has been submitted for Air Force-wide adaptation. Additionally, the wing publishes and distributes a bimonthly newsletter with the latest information about the CPFH process increases audience interest and awareness. Highly trained and informed personnel make smart maintenance decisions; smart maintenance decisions result in cost savings for the wing.

Another key to program success is due to senior leadership commitment and support. A flying-hour working group, commissioned by the wing commander and composed of members from financial management (FM) and the logistics and operations groups (LG/OG), meets monthly to review program issues and provide recommendations and direction. The wing commander is briefed monthly with program updates and provides valuable feedback and guidance in turn. Commitment from the top results in commitment at all levels.

Maintainers have a significant stake in the CPFH process. Not only must they know what the CPFH process is, they must couple this with the exercise of supply discipline and use of intelligent maintenance procedures. From the very beginning, many of the recommendations from the AFLMA study, LM931581, "Aircraft Depot Level Reparable Cost Per Flying Hour Lessons Learned," were adopted at Aviano. (3) The reduced CPFH for the first six months of fiscal year 1996 shows Aviano's success.

DLR Cost Savings Recommendations

Following are some commonsense recommendations for maintainers to facilitate DLR cost savings:

- Order only the parts required to fix the job.
- Completely and accurately fill out all Air Force Technical Order Forms 350, Reparable Item Processing Tag (AFTO 350). This is the audit trail for repair and reduces time spent in troubleshooting and repair.
- Maintain tight control over due-in-from-maintenance (DIFM). DIFM management is absolutely critical to cost savings. Rapid injection of parts into the repair cycle not only facilitates job completion, but increases the availability of funds for additional parts repair.
- Take the time to develop and use good troubleshooting skills.
- Follow technical data. If there are problems, take the time to identify them and submit the necessary paperwork to resolve them.
- Identify nonreparable parts as not reparable this station (NRTS) immediately. Do not hold onto what cannot be fixed. Valuable repair dollars are tied up, and, this may be the only available spare in the inventory.
- Repair to the lowest possible level authorized by technical data. If the repair can be taken one step further, submit a suggestion or give it to the Alternate Maintenance Concept (AMC) Consolidated Repair Facility (CRF) (Gold Flag) for evaluation.
- Limit cannibalizations to mission essential components only, and document all cannibalizations. Holding an item for the sake of cannibalization causes a spares shortage and adds to the cost of repairing the end item in terms of both money and man hours.
- Eliminate "swaptronics" between test stations. "Swaptronics" transfers failures from one test station to another. Playing "swaptronics" with multimillion dollar aircraft, pods, test equipment, etc., only costs more money over time.

Consumables Cost Savings Recommendations

Consumables cost savings are also possible, and the following is recommended:

- Order only what is required to accomplish a repair; do not order the "nice to haves."
- Question all expenditures. Performing an internal audit is the first step in controlling consumables costs.
- Lower the level of accountability and responsibility. Commanders should be aware of the money being spent on consumables, but it is the responsibility of every individual to spend money wisely.
- When performing repair, practice care when using tools and test equipment. Tool and test equipment parts cost make up a good portion of flying-hour consumables costs.
- Before throwing away XB3 and XF3 items, check with the AMC CRF (Gold Flag) to determine feasibility of repair. If an item can be repaired, develop the capability and have it approved.
- Determine personnel requirements for individual equipment (IE). Consider developing an IE folder on each person.
- Inventory current local purchase (LP) store items, establish real requirements, and allocate a certain target every quarter for LP items.
- Accomplish an item-by-item review of all bench stock items. Delete items not used for the last three to six months. Serviceable items not used and turned back into supply may result in credits to organizational accounts.
- Do not be afraid to say "no." If it does not sound right, chances are it is not right.

Changing costly maintenance practices is the single biggest roadblock to CPFH success. This means overcoming ingrained practices in maintainers. Establishing firm mission capable status (MICAPS) on every part without offering the back shop the opportunity to repair still occurs. Timely return of aircraft to mission capable status is essential; however, this practice effectively takes the back shops out of the repair process and contributes significantly to the cost of doing business. Firm up MICAP requisitions **after** determining the shop cannot accomplish the repair. This practice will be difficult to change and is a matter of balancing chargeable not mission capable, maintenance (NMCM) time versus chargeable not mission capable, supply (NMCS) time.

A brief word on AVPOL cost. The "fluid" nature of AVPOL continues to hamper efforts in accurately determining reasons for higher than recommended AVPOL consumption. Aviano's AVPOL consumption and CPFH are higher than the recommended consumption rates in AFI 65-503, *USAF Cost and Planning*

Factors, for F-16 C/D aircraft, and the reasons are a matter of speculation. (2) The operations group has more control over AVPOL costs than any other organization. Aircraft configuration, mission profile, sortie duration, number of deployments and their locations, air refueling operations, and type of fuel used (JP4/JP8) contribute to AVPOL CPFH. Many of these factors are beyond program control; therefore, accurate accounting of all fuel receipts continues to be the best available method in determining AVPOL CPFH. Monitor monthly consumption and closely examine any unusual monthly spikes. In simplified terms, AVPOL CPFH is a result of cost per gallon and total gallons consumed.

CPFH program success does not happen overnight. It takes months for the program to evolve into a tool useable for the wing. Count on a solid year of data collection and awareness raising before the program becomes a successful operation. Daily maintenance by personnel who know about the program, support for the program from every level, smart maintainers implementing and using smart maintenance and supply practices, and, most importantly, highly-trained personnel throughout the flying organizations contribute to reducing wing flying-hour cost. It requires time, patience, and perseverance, but the wing and, more importantly, the Air Force will eventually realize efficiencies and cost savings.

CPFH Tips to Remember

- If monthly expenditures increase or remain the same and flying hours decrease, CPFH will increase.
- AVPOL is "fluid" and hard to account for. Leave the responsibility for explaining AVPOL fluctuation to the operations group.
- Follow-up, investigate, and correct all program inconsistencies.
- Training for all personnel is the key to wing cost savings.
- Ensure credits from deficiency reports are accounted for and correct, but do not use them as a preferred method to reduce flying-hour costs.
- Smart people plus smart maintenance and supply practices equals wing savings.
- Become "in tune" with available technology: graphics programs, supply databases, the Internet, etc. Use technology to your advantage.
- Strive to be proactive; avoid being reactive.
- Know when to report and what to report. Report the news; do not make the news.
- Develop and maintain a good file plan. Historic data can make or break a CPFH program.

Additional Requirements

As of this writing, there exists no standardized database collection method to determine exact costs of specific weapon systems. A dBase IV program obtained by the Aviano CPFH office from the 52nd FighterWing, Spangdahlem Air Base, Germany, is being used and refined to execute program efficiencies. This program converts the Reparable Support Division Summary Report (D26) into usable information. This program is very helpful in determining such things as NRTS rates and item prices; however, it only sorts DLR items and is not able to determine specific weapon system CPFH. This continually improving program is an opportunity to replace the Reparable Support Division data consolidation program of the past. To date, use of this dBase IV program at Aviano has resulted in identification and recovery of over $1.5 million dollars in erroneous DLR charges. A similar program able to account for all spending activity, DLRs and consumables, and able to sort by specific weapon system work unit code will greatly benefit the entire combat air forces.

CPFH Program Direction?

The future of the CPFH program is unclear. Although sanctioned to report and monitor flying-hour costs, it is uncertain how information collected by the CPFH program is used in the fiscal year budget process. The need for the program has been established, but the program needs have not been defined. Several key questions about the CPFH program remain:

- Will the Air Force establish standards for determining and reporting CPFH? Capturing and accurately reporting all commodity costs, not just DLRs, is essential to ensure sufficient wing flying-hour funding levels from the MAJCOMs.
- When will an improved database be developed that will capture consumable and DLR costs?
- How is AFI 65-503, *USAF Cost and Planning Factors*, used to develop a CPFH program?
- How are the logistics cost factors related to AFCAIG rates?
- How important are weapon system and aircraft CPFH in determining future procurements?
- Will system mean time between failure rates and reliability and maintainability be balanced with system and aircraft CPFH?
- Finally, what does CPFH really mean? Without performance measures to gauge progress and attainable goals to strive for, the CPFH program becomes another data collection agency churning out reams of meaningless information in a futile attempt to justify expenditures.

Conclusion

Military members are stewards of the budget allocated by Congress; therefore, financial responsibility will become an important and added job skill for operators and maintainers. Proactive and visible training programs are also essential to the success of the CPFH program. Highly-trained personnel aware of their financial responsibilities in the flying program contribute significantly to reducing CPFH. The continued development and eventual implementation of a standardized CPFH program throughout the combat air forces is essential in the face of ever-shrinking defense budgets. The program at Aviano can be used as a cornerstone in the construction of a solid combat air force CPFH program.

References

1. Air Force Materiel Command. *Air Force Final Implementation Plan Stock Funding Depot Level Reparables DMRD 904,* Wright-Patterson AFB OH: AFMC, Jan 93.
2. Department of the Air Force. AFI 65-503, *USAF Cost and Planning Factors*, Washington DC: U.S. Government Printing Office, 6 Jan 96.
3. Schloz, L. J., Capt, USAF, and Capt D. W. Jones, USAF. "Aircraft Depot Level Reparable Cost Per Flying Hour Lessons Learned," Project No. LM931581, Maxwell AFB, Gunter Annex AL: Air Force Logistics Management Agency, May 94.
4. United States Air Forces in Europe. USAFEI 21-101, *Objective Wing Maintenance*, 9 Jan 95.

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Editor's Note:

The Air Force Logistics Management Agency (AFLMA) is currently analyzing the Cost-Per-Flying-Hour (CPFH) program. The following answers to the authors' questions about the CPFH program direction are provided by Captain Robbin Vaughn, the project manager for the AFLMA project LM9629920, "Analysis of the Air Force Cost Analysis Improvement Group Cost Per Flying Hour Process."

Background

The Air Force Cost Analysis Improvement Group (AFCAIG) rates for CPFH vary among major commands and wings with like mission design series (MDSs). During the 30 November 19 95 Supply Management Business Area General Officer Steering Group (GOSG) meeting, HQ USAF/LGSY (AFCAIG) was tasked to review and develop options for a standardized approach to CPFH for GOSG consideration. HQ USAF/LGSY tasked the AFLMA to evaluate the development process of the CPFH program package. The AFLMA is performing an exploratory analysis of the process used to build CPFH rates.

Questions and Answers

Q. Will the Air Force establish standards for determining and reporting CPFH? Capturing and accurately reporting all commodity costs, not just DLRs, is essential to ensure sufficient wing flying-hour funding levels from the MAJCOMs.

A. Yes. The AFLMA is currently studying the CPFH process. This project is attempting to define the purpose of the CPFH program, analyze the current CPFH development process, and streamline and recommend changes, if needed. The project is scheduled for completion in September 1996.

Q. When will an improved database be developed that will capture consumable and DLR costs?

A. At this time there is not a database under development to capture consumable and DLR costs. However, the new Integrated Maintenance Data System (IMDS), currently under development, will be able to enhance communication and increase visibility of assets and associated costs between maintenance, supply, finance, and transportation systems.

Q. How is AFI 65-503, *USAF Cost and Planning Factors*, used to develop a CPFH program?

A. AFI 65-503, *USAF Cost and Planning Factors*, is the compilation of the CPFH program. Data from the CPFH program is put into AFI 65-503. AFI 65-503 displays the rates and costs for different items including aircraft maintenance and personnel.

Q. How are the logistics cost factors related to AFCAIG rates?

A. The verified AFCAIG CPFH rates become the logistics cost factors.

Q. How important are weapon system and aircraft CPFH in determining future procurements?

A. Very important. CPFH rates are based on the cost of depot level reparables (DLRs) and consumables (General Support Division and Systems Support Division). The price of these parts include a surcharge. These surcharges are used to make future buys. Hence, today's prices includes tomorrow's purchases.

Q. Will system mean time between failure rates and reliability and maintainability be balanced with system and aircraft CPFH?

A. Yes. As we get a better handle on system mean time between failure rates and reliability and maintainability, we will see a decrease in overall CPFH. CPFH is a direct correlation of those factors and their associated costs to the Air Force. Any changes in those factors will eventually show up in the CPFH rate.

Q. Finally, what does CPFH really mean? Without performance measures to gauge progress and attainable goals to strive for, the CPFH program becomes another data collection agency churning out reams of meaningless information in a futile attempt to justify expenditures.

A. There are several definitions for CPFH depending on its intended use and level of decision making. However, CPFH is universally accepted as the budgeting and analysis tool for determining the Air Force's budget to fly airplanes. Technically speaking, the CPFH process is relatively simple. Last year's budget is used as a baseline; requirements are used as adjustments for the future. These rates are combined to form the CPFH rates.

Captain Vaughn is a project manager in the Maintenance and Munitions Division of the Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama.

Environmental News

A Lesson Learned: The Proper Disposal of Spent Lithium Batteries

Naval Air Station, Jacksonville, reported a fire in their hazardous waste storage facility in a drum containing spent lithium batteries. Batteries were discharged and packed with vermiculite in a 55-gallon drum. The next morning the drum began to vent sulfur dioxide gas. The manufacturer recommended that venting be allowed to continue until the reaction was complete. Two hours later hazardous waste handlers decided to move the drum outside to a bermed loading dock due to poor ventilation inside the hazardous waste building. The contents of the drum spontaneously ignited and fell from the forklift onto the outside loading ramp. The fire department extinguished the fire with sand in accordance with the manufacturer's recommendations.

The batteries involved in this particular incidence were Eternacell BA-560, Battery, Non-Rechargeable, NSN 6135-01-168-2944, manufactured by Power Conversion, Inc., Elmwood, NJ. Discussion with the manufacturer indicated that when the discharge switch is activated, all three cells are not fully discharged and the battery will attempt to recharge itself. When this occurs, a small amount of heat may be generated causing batteries to vent and release sulfur dioxide.

To avoid future similar incidents, the facility initiated new procedures which call for customer/generator to completely discharge the batteries in an open, well-ventilated area for five days prior to packing for disposal. This will ensure the batteries are fully discharged and any heat generated is completely dissipated. Batteries are then to be packed in individual ziplock plastic bags and covered with clay within the drums.

For more information, contact the Hazardous Waste Manager at NAS Key West, FL, at DSN 483-2583 or (305) 293-2583.

Reprinted from *Global Environment Outreach*, Vol 3, Issue 7, Air Combat Command and Radian Corporation, June/July 1996.

Managing Used Antifreeze

All ACC [Air Combat Command] bases generate used antifreeze from maintaining vehicles and refrigeration chillers. Most ACC personnel believe that used antifreeze is not a problem because it's recycled by distillation or filtration (e.g., "Bad Ethyl" distillation units and filtration units that recover usable antifreeze). However, improper management of used antifreeze has previously resulted in enforcement actions at some bases. If you're struggling with how to properly manage your used antifreeze, this article has some answers for you.

Used antifreeze falls into the regulatory category of *spent materials* —materials that have been taken out of service because they're contaminated from use (refer to 40 CFR 261.2). Hazardous waste regulations further categorize spent materials that are processed into usable products as *solid waste* (see 40 CFR 261.2, Table 1). These categorizations ultimately determine how used antifreeze must be managed even if it is reclaimed through distillation or filtration.

For used antifreeze that is recycled into usable products, generators must follow these steps:

- test the used antifreeze to determine if it is hazardous waste (40 CFR 262.11);
- if it tests as HW [hazardous waste], properly manage the used antifreeze as HW (40 CFR 261.6);
- accumulate the HW antifreeze in satellite or 90-day accumulation points IAW [in accordance with] all HW requirements and;
- transport the HW antifreeze off-site IAW proper HW manifest procedures.
- if required by state regulations, register and permit the recycling operation with the state.

HW rules do provide a few exceptions for used antifreeze.

- Used antifreeze that is reused in another piece of equipment without processing it first to obtain a usable product is exempt from HW regulations [40 CFR 261.2(e)].
- Used antifreeze that is recycled and returned *in a closed loop* to the original equipment item or vehicle is exempt from HW regulations. Closed loop recycling involves withdrawing the fluid, processing it into a usable product, and returning it to the original process in an engineered closed loop (all connections are piped and no storage unit or other container is attached to the recovery system.)

Bottom line: used antifreeze recycling operations are regulated in the same manner as spent solvents (e.g., Safety Kleen). Direct reuse of such materials or closed-loop recycling are excluded from regulation. Stay tuned for a future article on a ways to legally exempt spent antifreeze from HW regulatory requirements. (Dr Kaye Sigmon, ORNL [Oak Ridge National Laboratory], (423) 574-6658)

Reprinted from the *ACC ECAMP Examiner*, Vol 1, Issue 2, Air Combat Command and Radian Corporation, July 1996.

Improving the Air Force Logistics System—Getting Back to Basics

Douglas Blazer, PhD

Introduction

Theory of Constraints, Reengineering, Lean Logistics, Process Improvement Teams—it seems everywhere you turn these days someone is trying to redesign some part of the Air Force logistics system. Oh, it is in need of improvement, there is no doubt. And some of the proposals are radical. Some take an item manager perspective, while others view the problem from base level. All agree something is needed.

This article provides another view on what the Air Force needs from a recoverable spares logistics—requirements, allocation, and distribution—system. I begin by defining the goal of the Air Force logistics system and the criteria for an effective system. I then get back to basics. I discuss some inventory principles—academically proven and time tested applications for inventory management. Finally, I propose some actions the Air Force should take to meet its goal.

Goal of a Logistics System

The goal of the Air Force logistics system is to attain peacetime and wartime aircraft availability goals with the minimum amount of inventory and operating expense. This implies the Air Force should:

- Make resource allocation decisions based on the largest gain in aircraft availability.
- Minimize inventory investment (while still achieving the readiness goal).
- Maximize the use of existing inventory and resources (at minimal additional expense) to increase aircraft availability.

Criteria for an Effective System

To meet this goal, the Air Force needs a number of things. The Air Force wants credible requirements that relate to mission performance (aircraft availability). The budget levels must be dependable and credible; the Air Force needs to identify the mission impact of any funding changes to its requirement. The system must be responsive to the user—the operating major commands (MAJCOMs)—in both peace and war. Aircraft availability should drive execution (procurement, repair, and distribution) and the users must define the aircraft availability goals that dictate the priority of execution decisions (procurement, repair, and distribution). All subsystems must be motivated to optimize the system performance measure—aircraft availability. Therefore, all subsystems must have performance measures directly linked to weapon system availability.

The Air Force should identify and implement improved business practices. If these improved business practices incur a major effort or expense to implement, the Air Force should apply the improved business practices to the items that matter the most. For example, if it is not practical or economically feasible to improve a process for all items, then improve the process for the top five percent of the items.

Finally, since the Air Force depot manpower is reducing, it is important to make the system less manpower intensive. This means a simpler, more timely requirements system; one that requires less data or has a much improved database management system.

I think all can agree to the goal of a logistics system and the criteria for an effective system. Before I propose specific actions the Air Force should take, I will first discuss some basic inventory principles.

Inventory Principles

There are principles of inventory that have been tested and proven over time. Although these principles seem straightforward, inventory managers and logisticians responsible for developing and improving inventory systems tend to lose focus occasionally. I feel it is valuable to reiterate these principles.

System Optimization Models

All other things being equal, multiechelon, system optimization models will outperform nonoptimization, single echelon, single item models, especially if the system's measure of merit is the optimization goal. (7,10) So, for example, a multiechelon, multiindenture model that maximizes aircraft availability at minimum inventory cost will always outperform a single echelon, single item inventory requirements model. By outperform, I mean provide a higher aircraft availability at equal cost or provide equal aircraft availability at less cost. A RAND Corporation study showed for a group of F-16 items that three different multiechelon, optimization models resulted in 10% higher aircraft availability with the same inventory investment as the nonoptimal fixed safety level requirements model—the same model the Standard Base Supply System uses to compute demand levels. (4)

Besides determining inventory requirements based on the right objective function, these optimization models consider the entire system—both base and depot level and end item and their reparable subcomponents. System-wide visibility can improve inventory performance. System optimization models outperform nonsystem-wide (single echelon, single item) models. However, even if the requirements model is not system wide, visibility of all assets (and inventory performance) in the system can improve performance. For example, consider an item with insufficient assets at the depot, but with extra assets available at base level. The depot may needlessly procure more assets because of the lack of base asset visibility.

This system visibility example points out another fact: system suboptimization is very possible. For example; reducing transportation funding thereby increasing the pipeline and resulting spares cost; reducing consumable parts funding thereby increasing repair line stoppages and increasing spares and labor cost; and maximizing base-level repair thereby increasing Air Force labor costs.

Shorter Pipelines

Shorter pipelines mean less cost, better responsiveness, and better operational performance. Any efforts to reduce the time it takes to buy, repair, ship, and handle inventory can reduce inventory investment and/or operational downtime. Reducing the order and ship time (OS&T) one day reduces the computed Air Force recoverable item requirement by $17.2 million ($11.2 million for buy and $6 million for repair). (3)

Requirements Determination

Computing requirements is the most important determinant of how an inventory system performs. (4) Other areas—determining how to prioritize, buy, repair, and distribute assets—are also important. But regardless of how well one operates the system—how quickly assets are repaired and how well they are distributed—without the right mix of assets, the system will not perform effectively and efficiently. RAND showed despite using an "optimal" method to prioritize, repair, and distribute assets, without the right mix of assets, the optimal repair model results in lower aircraft availability than a system that optimizes the mix of assets and repairs nonoptimal, first-come, first-served. (4)

ABC Analysis

Another time-tested practice is called ABC analysis. (9) Basically, ABC analysis is based on observations that, typically, less than 20% of the items drive 80% of the cost (or activity) and 5% of the items account for the majority of cost. It recommends segregating inventory into three categories: (1) the most important (most costly) "A" (5%) items where it is cost effective to specially manage, (2) the important (relatively moderate cost) "B" (15%) items where it is cost effective to take some special management measures, and (3) the less important (relatively inexpensive) vast majority (80%) "C" items that do not require any special management actions. In short, it pays to handle classes of items differently and to control investment in ways which appropriately manage the high-cost items.

Forecasting Methodology

The next inventory principle comes from forecasting theory. Choosing a forecasting method should depend on the time horizon to forecast. (9) Generally speaking, inventory managers should use a different model for long-term (two to four years) forecasts than for short-term (two to four weeks) forecasts. Today the Air Force uses the same method, a two-year moving average, to forecast long-term budget and procurement actions (a two to five years forecast horizon) as it uses to forecast short-term repair (14 to 90 days).

Proposals to Improve the Air Force Requirements System

Keeping these inventory principles in mind, I propose a number of initiatives for the Air Force to improve its ability to meet aircraft availability goals with the minimum amount of inventory and operating expense.

(1) *Continue to reduce response times and change the pipeline requirements factors.* The current efforts to streamline depot and transportation pipelines have been effective. Reducing pipeline times for items in a buy requirement and/or high-cost repair should receive priority attention. Streamlining the process is only half the battle. The Air Force must also change the factors used to compute the pipeline requirements. Changing the factors will reduce buy amounts and decrease inventories.

(2) *Reduce the base portion of the pipeline to complement the depot and transportation process improvements.* Significant improvements have been made in depot and transportation pipeline performance. (2) However, the base portion of the pipeline still needs to be reduced. An Air Force Logistics Management Agency (AFLMA) study documents the improvement in retrograde and resupply time, but shows the times could be reduced further. (2) Additional savings is possible by improving the base process. The AFLMA is currently reengineering the base process. This is a worthy effort, and the Air Force should test the AFLMA reengineered process as part of PACER LEAN.

(3) *Repair, buy, and distribute (allocate levels) reparable assets based on aircraft availability goals.* Centralized, multiechelon optimization models are the way to go. The Air Force recently directed the implementation of Readiness Based Leveling (RBL) to set both depot and base levels. The RBL allocates the Aircraft Availability Model (AAM) computed worldwide requirement to minimize base-level backorders. The Air Force still needs to implement Execution and Prioritization of Repair Support System (EXPRESS), which appears best able to meet the Air Force needs to repair and distribute based on aircraft availability goals.

(4) *Continuously improve the database and requirements process.* The Air Force has recognized the need to improve the accuracy, validity, and responsiveness of the requirements system database. The Air Force Materiel Command (AFMC) has formed a Tiger Team to improve the accuracy of the requirements system database. The team consists of both retail and wholesale experts. Besides a "clean-up" of the databases, the team must put tools in place to continuously monitor the database and take corrective action when inaccuracies are found. For example, if base personnel identify an error in their base's data in the depot database, they should have the automated means to correct the error immediately (rather than the next quarterly report).

(5) *Form an Air Force Requirements Team.* The Air Force should establish a centralized requirements team at HQ AFMC/LG to continuously monitor the requirements models and their databases. The Team would consist of math modelers as well as functional database experts (similar to the HQ AFMC Requirements Interface Process Improvement Team or the Ogden team operating the Distribution and Repair in a Variable Environment). The team will monitor model policy input parameters as well as the data and make policy exceptions as necessary for individual items or circumstances. The teams could include MAJCOM liaison officers.

(6) *Reduce inventory for other (non-demand based requirements) major requirement categories.* The Air Force

analysis community meticulously reviews the models and policy used to compute the approximately $3 billion of Primary Operating Stock (POS) gross requirement. Comparatively little is done to analyze the significant amount (over $3.9 billion of additive, special levels, floating stock, and insurance item requirements) of the Air Force gross spares requirements not computed in the Air Force Recoverable Item Requirements System (D041). (3) If the Air Force is to significantly reduce inventory, it must find ways to reduce these non-demand based requirements. This includes exploring ways to reduce wartime nonoptimized (NOP) item requirements through improved forecasting, marginal analysis, regionalization, or consolidation. Similarly, the Air Force could find ways to consolidate and reduce additives for spares support lists (both initial and follow-on provisioning) and base adjusted levels.

(7) *Develop a credible Other War Reserve Materiel (OWRM) requirement.* The OWRM concept—those spares necessary over and above POS and Readiness Spares Packages (RSP) requirements to sustain the wartime operations tempo—is still valid. The OWRM requirement should consist primarily of component parts necessary to repair spares at the depot that fail at the bases in the first 30 days of the war and will be subsequently needed plus additional spares to replenish condemnations caused by the increased wartime tempo. The implementation of the OWRM requirement is more important with two levels of maintenance and Lean Logistics concepts because the depot is even more important to wartime support. A Logistics Management Institute (LMI) analysis showed both technical and conceptual problems with the current Air Force OWRM computation. (8) However, the Air Force OWRM requirement, although unfunded for years and not officially accepted, continues to be reflected in the D041 computation and Air Force Central Secondary Item Stratification (CSIS). As a result of a HQ USAF/LGS tasking, the LMI is working with AFMC to review and improve the Air Force's OWRM computation.

(8) *Develop "lean" retention policies.* As part of the analysis to determine how (and on what items) to reduce requirements, the Air Force should review its inventory stratification and retention policies and the implications of reducing the requirements with today's stratification and retention policy. For many items, reducing requirements will only increase the number of assets in long supply. Although the Air Force may choose to dispose of some assets in long supply, thereby reducing inventory, the economic benefits of disposal are small—the real goal is to reduce the requirement so the Air Force buys and repairs fewer items. Thus the Air Force could determine: (1) which items will yield the greatest improvement via application of process improvements, (2) how and when to reflect those process improvements in the requirement, (3) how to reflect the new requirements in the stratification, and (4) an appropriate retention/disposal policy.

(9) *Reexamine the benefits of the Reparable Stock Fund.* The Depot Level Reparable Stock Fund is approaching its fifth year. It may be time to revisit stock funding to determine if it has achieved its goals. More specifically, does stock funding support Lean Logistics and is it consistent with the centralized direction the requirements system is taking? RAND and LMI reports have questioned the costing methodology and suggest inaccurate pricing motivates ineffective (and costly) behavior. (1,6) The AFLMA's two-level maintenance analysis indicates stock funding motivates bases towards more base-level repair—a trend contrary to two-level maintenance. (5)

Conclusion

The Air Force recoverable logistics system is benefiting from the review provided by all the efforts aimed at improving it. These improvement efforts should share a common goal and be based on solid inventory theory and principles. It is time for a change, and I believe my proposals will provide the basis for improving the Air Force's recoverable spares requirements, allocation, and distribution system.

References

1. Camm, Frank, and H. L. Shulman. "When Internal Transfer Prices and Costs Differ: How Stock Funding Depot Level Reparables Affects Decision Making in the Air Force," RAND Corporation, Undated.
2. Hession, Ken, Capt, USAF, et al. "Retrograde Analysis for the WR-ALC Lean Logistics Shop Demonstration," Project No. LS9504500, Maxwell AFB, Gunter Annex AL, Air Force Logistics Management Agency, Aug 95.
3. King, Randall. "Inventory Impacts of Lean Logistics," Logistics Management Institute Briefing Presented to the Air Force Supply Executive Board, 9 Feb 95.
4. Miller, Louis W., and John B. Abell. "Evaluation of Alternative Approaches to Central Stock Leveling," Draft Report DRR-936-Air Force, RAND Corporation, Dec 94.
5. Murray, Norman, Maj, USAF, et al. "Assessment of 2LM Cost Estimating Procedures (F-16 Avionics)," Project No. LM9500300, Maxwell AFB, Gunter Annex AL: Air Force Logistics Management Agency, Jan 96.
6. Rogerson, William P. "On the Use of Transfer Prices within DoD: The Case of Repair and Maintenance of Depot Level Reparables in the Air Force," Logistics Management Institute Report PA303RD2, Mar 95.
7. Sherbrooke, Craig C. *Optimal Inventory Modeling of Systems*, New York: John Wiley and Sons, Inc., 1992.
8. Slay, Michael F. "Analysis of the Air Force Other War Reserve Materiel Requirements Computation," Logistics Management Institute Briefing Book AF101LN1, Mar 92.
9. Tersine, Richard J. *Principles of Inventory and Materials Management*, Fourth Edition, Englewood Cliffs, NJ: Prentice Hall, Inc., 1994.
10. Wagner, Harvey M. *Principles of Operations Research*, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1969.

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Predicting Wartime Demand for Aircraft Spares

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Introduction

United States fighter aircraft demanded surprisingly few spare parts in DESERT STORM despite flying long hours. Although the sorties flown were much longer than their peacetime counterparts, demands per sortie remained about the same. This simple observation raised suspicions that parts fail on the basis of sorties flown, not hours flown, even though Air Force planning systems forecast demands on the basis of projected flying hours.

In 1993, the Air Force revised the *USAF War and Mobilization Plan, Volume 5 (WMP-5)* to account for the longer sortie durations expected when responding to future regional contingencies. (3) Had the Air Force continued to assume demands are proportional to flying hours, the wartime spares requirement would have increased dramatically. Furthermore, unit capability assessments would have been too low to be credible. Since this situation would be unacceptable, the Air Force operations and logistics communities agreed to a moratorium on implementing the revised *WMP-5* until a better demand forecasting method could be found.

Because wartime demand is predicted from peacetime data—and these predictions drive inventory investment and capability assessments—it is critical to know whether spares demand is really determined by the number of sorties, by flying hours, or by some combination of them. Our analysis confirmed demand is indeed much more closely related to sorties than to flying hours. The Air Force is now incorporating the results of our research in its computation of wartime spares, avoiding a $1.1 billion overstatement in the gross requirement. The wartime spares investment resulting from implementing the revised war plans—along with the new method of computation—changes only modestly, and unit capability assessments are more realistic.

We begin with a review of previous research and then examine some DESERT STORM findings. Then we review the analysis of F-15C/D and other tactical aircraft data sets. From this, we develop a new demand model and then look at some practical considerations.

Previous Research

Quantitative Studies of Maintenance Removals Versus Sortie Duration

In peacetime, the average sortie duration is fairly consistent from year-to-year, making sortie duration and flying hours convenient methods for predicting peacetime spares demands. A number of studies performed in the 1960s and 1970s used regression analysis to explain maintenance removals per sortie, Y, as a linear function of the sortie duration in hours, x (see Equation 1). (1,6) Because spares demand data were often unavailable, unscheduled maintenance removals were used as a surrogate. Colonel C. C. Shaw, who performed many of these analyses, chose to express the relationships as a constant term representing maintenance removals arising from a one-hour mission plus a variable for the additional removals for durations beyond one hour:

$$Y = a + b(x-1).$$

Equation 1

where a and b are regression coefficients that vary by aircraft.

To enable comparison between aircraft with very different failure rates, we must factor out the coefficient "a" to normalize the incremental removals per hour. Thus the regression model becomes:

$$Y = a\left[1+\frac{b}{a}(x-1)\right].$$

Equation 2

The normalized slope (b/a) is the fractional increase in maintenance removals per additional hour of sortie duration. Table 1 gives this normalized slope as derived from various previous studies. (1,4,6) Using as an example the bottom line in Table 1, we see that for the B-52D aircraft, the normalized slope is 20%. In other words, for each hour of sortie duration in excess of one hour, the number of unscheduled maintenance removals increases by 20% of the baseline (one-hour) rate. Alternatively, we could say the B-52D maintenance removals were 20% flying-hour driven (80% sortie driven). We will use this definition later in this article.

What can we conclude from Table 1? A normalized slope of 0% would indicate maintenance removals are purely sortie driven. On the other hand, a 100% slope would indicate removals are purely flying-hour driven. All of the slopes in Table 1 fall between these extremes, averaging about 19%. The slopes are much closer to 0% than to 100% suggesting demand is much more closely related to the number of sorties than to the number of flying hours.

However, the studies cited are of only limited relevance to current tactical fighter aircraft, for three major reasons:

- The average sortie durations, in those studies, are much longer than typical fighter sortie durations. The transport

Aircraft	Systems	Normalized Slope (%)	Number of Sorties Examined	Author	Date
C-5A	All	5	79,181	Shaw	1980
C-5A	Engine	8	79,181	Shaw	1980
C-141	All	28	835,000	Shaw	1980
C-141	All	22	73,000	Shaw, Howell	1980
C-130E	All	33	45,000	Shaw, Howell	1980
B-52D	All	20	10,809	Boeing	1970

Table 1. Regressions of Maintenance Removals on Sortie Duration

aircraft have average durations of about 4.5 hours; the B-52D about 8 hours.

- Each aircraft was flying only one type of mission, while tactical missions tend to encompass a variety of mission types.
- The data is over 15 years old.

Another problem with data such as these that have not been collected in a controlled experiment is most of the sortie durations were clustered about the average. For example, 80% of the transport sorties were between three and six hours. The only exception is the B-52D data, which were collected from three bases flying combat missions in the 1960s. Since average durations for the three bases were 4, 8, and 11.2 hours, the dispersion was particularly good for studying the impact of sortie duration on maintenance removals.

DESERT STORM Experience

During the first 30 days of DESERT STORM, one F-15C squadron of 24 aircraft we examined, flew 236% of its planned *WMP-5* flying hours but only 85% of the sorties (Table 2). Furthermore, observed demand rates were much lower than those expected from pure flying-hour-based demand forecasts. On an item-by-item basis, 214 of the items were better estimated by a pure sortie-based forecast, 58 by a pure flying-hour-based forecast. Similar results were obtained for a group of 72 F-16C/D aircraft. These results are consistent with the literature review and support our suspicions about using pure flying-hour-based demand forecasts for building and assessing wartime spares requirements.

Data Category	F-15C	F-16C/D
DESERT STORM as a Percent of Planned Activity		
30-Day Number of Flying Hours	236%	142%
30-Day Number of Sorties	85%	91%
Accuracy of Forecasted Item Demands Per Flying Hour		
Over-Predicted by More Than 25%	84%	81%
Within +/- 25%	7%	10%
Under-Predicted by More Than 25%	9%	9%
Number of Items Predicted Better by		
Flying Hours	58	23
Sorties	214	117

Table 2. DESERT STORM Data

Data Analysis: An F-15C/D Case Study

We analyzed two types of data from the Core Automated Maintenance System (CAMS): operational (tail number, sortie length, time, location, and mission type) and maintenance (tail number, start time, work unit code (WUC), how malfunctioned, when discovered, and action taken). * We could not tie supply data to sorties, so we used maintenance removals as a surrogate for demands on supply. Detailed results are presented for the F-15C/D at Langley AFB, Virginia, from January through late September 1993, followed by summaries of those for other tactical aircraft with *WMP-5* wartime tasking. We excluded all tail numbers that were deployed to Southwest Asia in this period, since their mission types and utilization were quite different. We begin with noting some confounding effects which had to be controlled for in the analysis.

Identifying Confounding Effects

For the 68 aircraft in our database, aircraft that flew only once on a particular day had the most demands. When an aircraft flew multiple sorties during a day, demands were much lower and tended to decline slightly with each succeeding sortie, except for the final sortie of the day, when the rate was almost as high as for an only sortie of the day (Table 3, next page). While sortie number has never been identified as an important variable in any previous study, it has emerged as a significant variable in our research.

Differences in mission type also caused large differences in demand rates (Table 4, next page). During aerial combat training sorties, the aircraft are heavily stressed and may pull as much as eight Gs. In contrast, cross-country training sorties tend to be longer and less stressful, as are training deployment sorties. Because the shorter sorties tend to be more stressful missions, this table shows **higher demand rates associated with shorter sorties.** If we had not accounted for the effect of mission type,

* The maintenance history records of interest are those for on-aircraft removals, excluding cannibalizations and those items removed to facilitate access to other items. We excluded maintenance removals with How Malfunctioned codes indicating No Defect. WUCs 0–09 were excluded because they are aircraft servicing codes. Technical Order Compliance items were excluded since they are not due to activities from the previous sortie. We excluded Time Change items as well, since these depend on number of hours or sorties, not activities from the previous sortie. We linked the maintenance start time to the previous sortie, except that we excluded sortie aborts (When Discovered = C) because, by their very nature, they generally reflect shortened sorties. When Discovered = K, M, and Q records were excluded because they reflect hourly post-flight or special inspections, were few in number, and not usually related to activities during the previous sortie.

it would have overwhelmed any positive relationship between demands and sortie length.

Sortie Number of Day	Number of Sorties (Hours)	Average Length	Average Demands/Sortie
Only Sortie of Day	1,857	1.54	0.62
1 of Multiple	2,804	1.35	0.17
2 of Multiple	796	1.22	0.14
3 of Multiple	418	1.15	0.12
4 of Multiple	178	1.12	0.10
5 of Multiple	45	1.00	0.11
6 of Multiple	1	0.90	0.00
Final of Multiple	2,820	1.33	0.52
Overall Total/Weighted Average	8,919	1.36	0.37

Table 3. Impact of Sortie Number on Langley F-15C/D Demand

Mission Type	Number of Sorties (Hours)	Average Length	Average Demands/Sortie
Aerial Combat Training	7,247	1.32	0.39
Cross-Country	498	1.47	0.15
Training Deployment	973	1.64	0.27
Other	201	1.23	0.56
Overall Total/Weighted Average	8,919	1.36	0.37

Table 4. Impact of Mission Type on Langley F-15C/D Demand

In analyzing demand rates for aircraft based at multiple sites, we found pronounced location effects. For example, in the case of the A-10, there were six regular USAF bases with a high average of 0.29 demands per sortie and eight Air Force Reserve/ National Guard bases with a low average of 0.12 demands per sortie. It is important to control for these location effects to avoid a spurious high slope, which could result because the high-demand-rate bases had a longer average sortie duration of 1.83 hours as opposed to 1.56 hours for the low-demand-rate bases. Similar differences between Reserve/Guard and regular USAF bases were found for the F-16.

Modeling Demands Versus Sortie Duration

We analyzed as a group the 7,108 aerial combat training missions that took off and landed at Langley. This group comprises most of the sorties in the data, yet is unbiased by the impacts of mission type and location. We noted one of the highest demand rates was for the group of 177 sorties lasting less than 0.8 hours. We excluded these sorties because of their high prevalence of functional check flights and air aborts. Functional check flights are very short, very-high-failure post-maintenance test flights. Theoretically, air aborts should be included, but tabulated according to the planned sortie duration, not the actual, shortened duration resulting from the air abort. Unfortunately, planned sortie duration was not available.

The resulting regression was for sortie durations between 0.8 and 7.3 hours and includes 7,020 sorties. The regression has a slope of about 18% and is statistically significant at the 95% level (there is less than a 5% chance that such a large slope could occur by chance absent any real relation between sortie duration and demand).

As noted earlier, in our discussion of Table 3, the impact of only/last sortie in comparison with other sorties is very large. It is statistically more significant than sortie duration even after the short sorties are eliminated. We found most of the difference in demand rates between earlier sorties of the day and the last sortie of the day results from deferred maintenance, not grounding breaks. Thus the demand rate after earlier sorties is understated and the demand rate after the last sortie is overstated. Since we are trying to relate the actual demand to each sortie, we define an early/last sortie variable that assumes a value of *minus one* on the earlier sorties, a value of *one* on the last of multiple sorties, and a value of *zero* on the only sortie of the day. We estimate the magnitude of this deferred maintenance by a regression assuming the amount of overstatement on the last of multiple sorties equals the amount of understatement on an earlier sortie.

When this variable for earlier/last sortie and sortie duration is used as independent variables in a multiple regression, the slope for demand as a function of sortie duration drops to 13% (still statistically significant). The smaller slope results because the last sortie of the day, which has more demand, tends to be slightly longer, as can be seen in Table 3.

Figure 1 is a scatter-plot of three F-15C/D data sets (normalized to a one-hour average sortie duration):

- The 1993 Langley training missions (from CAMS data discussed earlier).
- The 1993 Dhahran SOUTHERN WATCH missions (from the CAMS data for 1,224 Saudi Arabia sorties with an average duration of 3.29 hours).
- All 1994 F-15C/D sorties (data for 20,060 sorties with an average sortie duration of 1.57 hours, from the Reliability and Maintainability Information System (REMIS), which is a worldwide roll-up of base-specific CAMS data).

Each point on the scatter-plot represents all the sorties at a particular sortie length. For example, the extreme right-hand plus sign represents seven 6.0-hour sorties. Unfortunately, there were few Langley training sorties above three hours and few Dhahran sorties above four hours.

Thus, many of the points on the right-hand side of the graph represent only a few sorties. Even though we could not show the number of sorties for each point in the figure, all regressions and mean-square error calculations weight those points by their number of sorties.

Mean-Square Error Validating Data Set

Visually, the data in Figure 1 seem closer to the 0% slope than to the 100% slope, but we used the 1994 REMIS worldwide data to confirm this.

Table 5 assesses five candidate models against the 1994 F-15C/D REMIS data, showing the mean-square error for each. In addition to the models based on pure flying hours, pure sorties, and 10% flying hours/90% sorties, we also considered a nonlinear model and a piecewise linear model. Clearly, the data does not support using a pure flying-hour-based forecast.

The parabolic model is a compromise between the pure sortie model and the pure flying-hour model. The parabolic model assumes demand is proportional to the square root of sortie length. This nonlinear function produces a parabolic plot of demands versus sortie length.

The 40%;6% flying-hour model is a piecewise linear model that assumes demands are 40% flying-hour/60% sortie dependent

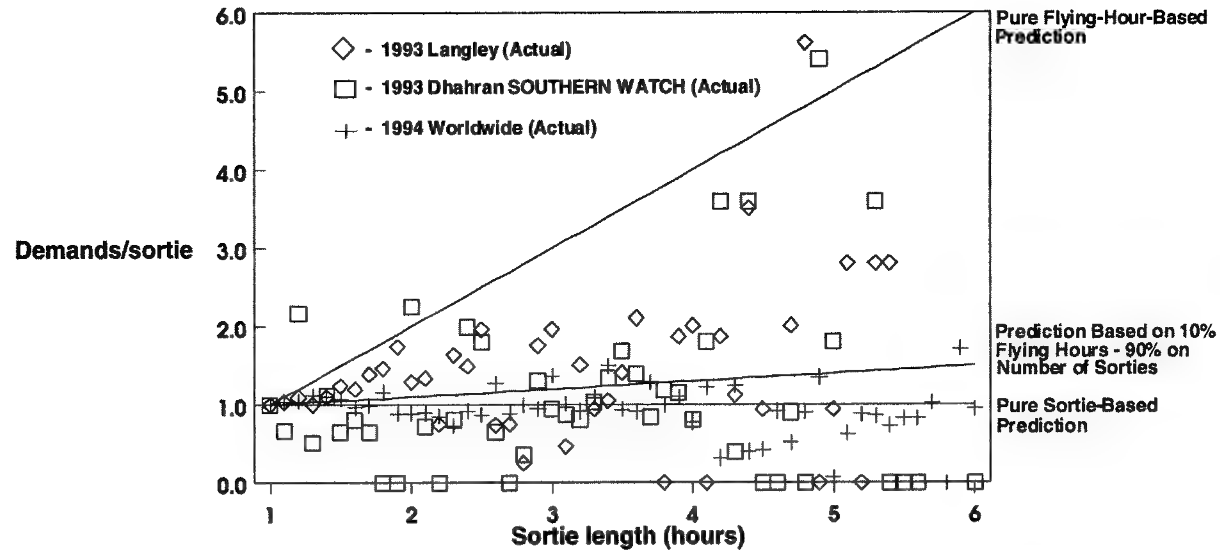

Figure 1. Predicted Versus Actual Demands for the F-15C/D

Model	Mean-Square Error
Pure Flying Hours	0.1001
Pure Sorties	0.0048
10% Flying Hours	0.0085
Parabolic	0.0234
40%;6% Flying Hours	0.0101

Table 5. Model Evaluation Versus 1994 F-15C/D REMIS Data

for sorties up to 1.5 hours and 6% flying-hour/94% sortie dependent above 1.5 hours. This piecewise linear function was the best fit for the 1993 Langley CAMS data. Yet, when this model was used to compute a readiness spares package (RSP), the spares mix was nearly identical to one computed using the simple 10% flying-hour model.

Analysis of Other Tactical Aircraft Data Sets

We repeated the analysis for several additional worldwide REMIS data sets. As with the Langley F-15C/D data, in each case we found a distinct only/last sortie of the day effect. Unlike the Langley case, this analysis was limited to training missions worldwide between 0.9 hours and 2.5 hours in duration. As we explained earlier, very short sorties often represent functional check flights or air aborts and thus are unusable. Long flights tend to involve landing at remote locations, a situation where maintenance is often deferred. Since REMIS does not include landing location, the only way to eliminate remote landings was to drop all long sorties. Had we not dropped these longer sorties, the regression slopes would have been even lower.

Table 6 shows the normalized slope of demand as a function of sortie length obtained by regression for each data set. The first column of numbers is the regression slope, where the independent variable is sortie length and the dependent variable is demand. The second column is the slope, taking into account the impact of earlier sortie versus last sortie of multiple sorties during the day. As with the Langley F-15C/D, accounting for last sortie effects usually lowers the slope, because the last sortie often has a high demand rate (as a result of deferred maintenance) and is longer.

Half of the entries in both columns of slopes are zeroes, because the slope from regression was negative and a negative slope is ruled out by the physics of our problem. (An aircraft with a given number of demands after a certain number of hours in a sortie cannot reduce the number of demands by extending the length of the sortie.) The number of sorties in the last column pertains to the number of observations used in each regression, but there were over 300,000 sorties in total from which these training sorties were extracted.

System	Slope Before Adjustment for Sortie Number	Slope After Adjustment for Sortie Number	Number of Sorties
A-10, OA-10	10*	6*	30,967
F-15A	0	0	10,903
F-15C/D (Langley Only)	18*	13*	7,020
F-15C/D (1993 Worldwide)	0	0	15,071
F-15E	0	0	11,623
F-16C	16*	10*	121,665
F-111F	8	8	2,631
F-117A	0	0	8,794
Overall Weighted Average/ Total	12	7	208,674

*Statistically significant at 95% confidence level.

Table 6. Summary of Slopes (Percent)

At the bottom of Table 6 we have computed weighted average slopes of 12% before adjustment for earlier/last sortie and of 7% after adjustment. While we believe that the slopes after adjustment for early/last sortie of the day are the more meaningful, those before adjustment are also shown, because they are comparable to the slopes found in other studies such as those in Table 1, where early/last sortie was not considered.

Model Selection

While the linear regression model may not be perfect, it is a good choice for several reasons:

- It is the simplest model, with only two parameters (slope and intercept).
- We have no empirical evidence to guide us in locating the knee between two linear segments or in determining the amount of curvature in a nonlinear segment.
- Our experiments with piecewise linear regressions yielded only a negligible difference in the spares computed in comparison with those computed using a linear regression.
- It is readily implementable with our existing data systems and inventory models.

We believe a 10% slope provides a reasonable overall planning factor for the impact of sortie duration on demands by tactical aircraft. This implies for each hour in excess of a one-hour sortie, the expected demand is increased by 10%. That is, a two-hour sortie has an expected demand of 110% of that of a one-hour sortie, and a three-hour sortie has 120%, etc., which is equivalent to saying that demands are 10% flying-hour driven and 90% sortie driven. This has been called demand deceleration and is depicted in Figure 2.

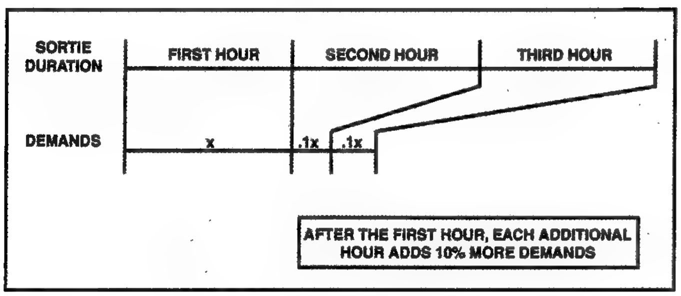

Figure 2. Demand Deceleration

As a simple solution that can easily be implemented across all tactical aircraft, a 10% slope, as stated above, represents a reasonable overall planning factor for the effect of sortie duration on demands. Of course, there is no doubt some components' demands have a greater relationship to flying hours than a 10% slope, while others' slope would be less. Although we could not identify them, we encourage others to try. Whatever the case, however, overall demand is clearly much more related to sorties than it is to flying hours.

Practical Considerations

Theoretically, the proposed model is sound, but there are practical questions. How much will using this method change the Mobility Readiness Spares Packages (MRSPs)? How robust will the new MRSPs be? What are the risks if wartime demands turn out to be significantly different from those anticipated?

Cost Impact With the 1993 *WMP-5*

This project began as a response to problems caused by using traditional flying-hour-based demand forecasting methods with the 1993 *WMP-5*. For almost every fighter in the Air Force, MRSP costs rose precipitously (Table 7) with this approach.

Not only were these MRSP kit costs unaffordable, but given DESERT STORM experience, they were not credible. In response to this problem, the Air Force put a moratorium on using the 1993 *WMP-5* to compute MRSP requirements and assessments until a better demand forecasting method could be found. An exception was made for the F-15E, because its kit costs went down even using traditional demand forecasting methods.

Mission Design Series	Primary Aircraft Authorization	1986 *WMP-5* Cost ($ Millions)	1993 *WMP-5* Cost ($ Millions)
A-10A	24	4.0	5.5
F-4G	12	33.0	60.3
RF-4C	18	11.0	13.3
F-15C/D	18	14.7	41.2
F-15E	18	31.6	23.6
F-16C/D	18	8.6	9.0
F-111F	18	81.0	109.3
F-117A	18	25.4	35.0

Table 7. Cost Impact of *WMP-5* Changes

As this research was being conducted, the Air Force was also implementing the two-level maintenance (2LM) initiatives. Therefore, our study focused on comparing the "old" MRSP cost (computed using the 1986 *WMP-5* and the traditional, pure flying-hour-based demand forecasting method) with the "new" MRSP cost (computed using the 10% deceleration method, the 1993 *WMP-5*, and incorporating the new 2LM initiatives). We used representative contingency kits and recomputed them both before and after all the changes. The resulting kit costs, and their associated weight and volume (or cube), are shown in Table 8. Note: the F-15E before data are based on the 1993 *WMP-5*.

Risk Analysis

However comforting the statistical results and cost stability may be, the mix of parts in the kits changed. These are new kits, built for a new tasking, using a new method. Any confidence in them has to be earned. They must be tested for robustness, particularly with respect to flaws in the new forecasting technique. In other words, will the new kits be adequate if wartime demands turn out to be different from those predicted from our research? What will happen if the differences are substantial?

To answer these questions, we looked at kit robustness from two perspectives. First, we used a Monte-Carlo simulation model to measure how many sorties would be lost under various demand scenarios. Second, for each of those same scenarios, we used a specially modified version of the Aircraft Sustainability Model (ASM) to calculate how much materiel would have to be delivered to a squadron to restore it to its direct support objective (DSO) (the minimum number of available aircraft that can support the flying program).

We used 400 replications to obtain a high degree of precision (it is practical to run that many on a fast personal computer). With 400 replications, most of the results were accurate to within 0.5%.

Each kit was then subjected to some rigorous scenarios. Since demands are modeled as 10% flying-hour driven (90% sortie

driven), how would the kits perform if demands were actually 20% flying-hour driven (80% sortie driven)? Also, as a worst case, how would the kits hold up if demands turn out to be 100%. Table 9 summarizes the results.

It is clear the risk of lost sorties is very low in the 20% flying-hour case. Thus, even if our model is wrong by a factor of two, few sorties will be lost. The pure flying-hour analysis represents an extremely unlikely worst case. Yet, even then all the mission design series except the F-15C/D lose fewer than 10% of their sorties.

Next, in each of these same cases, how much materiel would need to be delivered, Desert Express style, to restore a squadron to its DSO?* To answer this, we modified the ASM to calculate only those backorders that caused the number of available planes to drop below the DSO. Using each weight and cube, the total 30-day Desert Express requirements were computed (Table 10).

Note that these figures represent the total for 30 days—not the daily requirement. Thus, even if our 10% model is wrong by a factor of two, it takes very little in the way of deliveries to the squadron to make up for the shortfall.

These results give us confidence that the 10% deceleration method will not put units at risk. With that, we can move on to implementation.

* Military Airlift Command (MAC) [now Air Mobility Command (AMC)] addressed weaknesses in the priority system by setting up a special airlift route, "Desert Express," to move critical parts to the Gulf quickly. By the end of October 1990, a MAC cargo aircraft flew daily to the theater from Charleston AFB, South Carolina, with the most critical parts needed for wartime readiness. (5)

Implementation

We selected the 10% method partly because of its simplicity and ease of implementation. With this method, no reprogramming of the logistics models is needed. The sortie duration is simply decelerated and the inputs to the models (flying hours) are adjusted accordingly.

Unfortunately, the task is still tricky. The mathematics of computing the decelerated sortie durations and flying hours must compensate for the effects of decelerating peacetime sorties. To simplify the process, decelerated sortie durations have been incorporated into the RSP Authorization Document—Blue

Mission Design Series	Kit Cost ($ Millions)	30-Day Desert Express Requirement: Demands Purely Flying-Hour Driven Pounds (Cubic Feet)	30-Day Desert Express Requirement: Demands 20% Flying-Hour Driven Pounds (Cubic Feet)
A-10A	4.4	133 (18)	17 (3)
F-4G	32.2	803 (64)	28 (2)
RF-4C	6.7	1,248 (124)	30 (3)
F-15C/D	16.5	5,540 (421)	171 (12)
F-15E	19.7	613 (63)	53 (6)
F-16C/D	3.6	157 (17)	5 (1)
F-111F	83.8	447 (61)	63 (8)
F-117A	27.4	1,380 (201)	104 (15)

Table 10. Risk Assessment—Materiel Required to Restore Squadron to Direct Support Objective if Demands are Based Purely by Flying Hours and 20% Flying Hours

Mission Design Series	Primary Aircraft Authorization	Before			After		
		Cost ($ Millions)	Weight (Pounds)	Cube (Cubic Feet)	Cost ($ Millions)	Weight (Pounds)	Cube (Cubic Feet)
A-10A	24	4.0	23,000	1,900	4.4	23,000	2,000
F-4G	12	33.0	28,400	2,700	32.2	26,500	2,400
RF-4C	18	11.0	19,600	2,000	6.7	13,900	1,400
F-15C/D	18	14.7	22,000	2,000	16.5	22,000	2,000
F-15E	18	23.6	19,000	1,500	19.7	15,000	1,200
F-16C/D	18	8.6	20,000	1,900	3.6	10,000	800
F-111F	18	81.0	68,000	7,300	83.8	69,000	7,300
F-117A	18	25.4	32,000	3,200	27.4	37,000	3,800

Table 8. Cost, Weight, and Cube Impact of New Method

Mission Design Series	Kit Cost ($ Millions)	Percent of Total Sorties Flown: Demands Purely Flying-Hour Driven	Percent of Total Sorties Flown: Demands 20% Flying-Hour Driven	Percent of Total Sorties Flown: Demands 10% Flying-Hour Driven
A-10A	4.4	99.3	99.9	100
F-4G	32.2	90.0	99.5	100
RF-4C	6.7	94.5	99.9	100
F-15C/D	16.5	80.8	99.2	100
F-15E	19.7	98.3	99.8	100
F-16C/D	3.6	98.9	99.9	100
F-111F	83.8	100.0	100.0	100
F-117A	27.4	96.6	99.9	100

Note: The F-111F has a high DSO. Thus, the kit has the reserve capacity to fly the full program even under extreme conditions.

Table 9. Risk Assessment—Percentage of Planned Sorties Based on Demands Driven Purely by Flying Hours, 20% Flying Hours, and 10% Flying Hours

Book. (2) All requirements and assessment computations are based on the figures in that document. Adding a few columns to the appropriate tables in the Blue Book sped implementing demand forecasting. The revised Blue Book has been published, and major commands are providing additional guidance in its usage.

Conclusion

As the Air Force evolves from a global warfare to a major regional contingency orientation, it will require continually reexamining logistical assumptions that have held sway for many years. For example, we found demands per sortie do not vary in a one-to-one proportion with sortie length as pure flying-hour-based forecasts assume. For the Air Force, this means pure flying-hour-based forecasts are inappropriate when extrapolating peacetime demand data to significantly different wartime flying programs. In this case, decelerating the sortie length results in a much more accurate demand forecast.

While the truth is closer to the pure sortie model than to the pure flying-hour model, demands are still influenced by flying hours. In fact, spares demands for fighter aircraft appear to be approximately 10% flying hour and 90% sortie driven. This finding enabled the Air Force to avoid a $1.1 billion overstatement in wartime spares requirements when it implemented the 1993 *WMP-5* for fighters. Furthermore, decelerated demand forecasts will also sharpen MRSP capability assessments.

Although decelerated demand forecasts do affect the size and cost of MRSP kits, the risk to tasked sorties is small. Even if demands were twice as sensitive to flying hours as the regression showed, every MDS examined could still perform over 95% of its tasked wartime sorties. This risk can be further mitigated with a very small amount of Desert Express-type shipments. While no demand forecasting method will ever be perfect—that is why the Air Force buys safety stock—the new method represents a vast improvement over the old one. It is simple, conservative, and easy to implement.

References

1. Boeing Military Airplane Systems Division. *B-52 Operations in Southeast Asia versus CONUS,* D162-10015-1, Seattle, WA, Sep 70.
2. Department of the Air Force. *1995 Readiness Spares Package (RSP) Authorization Document, Vol 1, Airborne,* Washington DC: HQ USAF/XOXW/LGS, Sep 95.
3. Department of the Air Force. *USAF War and Mobilization Plan, Volume 5 (WMP-5): Basic Planning Factors and Data,* Washington DC: HQ USAF/XOXW, Mar 93.
4. Howell, Lawrence D., Capt, USAF. *A Method for Adjusting Maintenance Forecasts to Account for Planned Sortie Lengths,* ASD-TR-78-26, Aug 78.
5. Keaney, Thomas A., and Eliot A. Cohen. *Gulf War Air Power Survey Summary Report,* Washington DC: U.S. Government Printing Office, 1993.
6. Shaw, C. C., Col, USAF. Saber Sustainer Briefing, AF/SAGM, Mar 81.

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Royal Air Force Spares Forecasting in World War II

Robin Higham, PhD

Early investigations into the spares problems of the British Royal Air Force (RAF) in World War II suggests that many hidden human failings delayed the impact of airpower until late into the war.

For example, in September 1939 when war broke out, the RAF had some 59 types of aircraft in the inventory or on order. Even though these aircraft contained standardized items for which tool kits were issued to mechanics, had standard blind-flying instrument panels in the cockpits, and standardized placement of instruments, much was missing and complicated by the revolutions taking place in aviation. New airframes, new engines, and new ancillary equipment were becoming available, but many items were nonstandard because they had not yet been proofed, approved, and ordered in quantity.

A second problem was how to order spares. It was envisaged almost exclusively on a peacetime basis. The trouble was, the spares system was geared to peacetime, where only one or two squadrons of a particular type aircraft were flown very few hours with gentle professional handling. From 1934 onward, however, the RAF was in rearmamental instability. Under a situation of rapid change, it was hard to know how to order spares when there was little experience with a certain aircraft type. Moreover, factories did not wish to produce spares, as they only got credit for complete aircraft.

The rule of thumb was that an aircraft type should be ordered with a 27-month package of spares for peacetime operations plus additional spares for 4 months of war. Due to bureaucratic lag, the spares were not ordered until after the manufacturing program had begun. Attempts were still going on three years after the war started to get factories to allocate 10% of their floor space to the manufacture of spares or to allow outside subcontractors to do the work. When the initial approach was found incompatible with factory work loads, or as some said, with the fact that the factories simply were not interested in damaging their production record, the Ministry of Aircraft Production decided to cut the requirements to a 15-month peacetime and 4-month wartime stock of spares. But then it was pointed out that less than an 18-month supply would not allow enough experience upon which to base future orders for spares based upon actual consumption of individual items. To that dilemma was added an additional demand for new parts for repairs. In fact, by mid-war some 40% of the British operational aircraft available in the United Kingdom (UK) were rebuilds.

Part of the problem was that prewar discussions, until just before war broke out, did not cover the matter of repairs, but did contain the idea that within three months of the outbreak of war, factories would be running at full wartime capacity. Part of the reason for this naiveté came from a failure to study World War I. Though it was true staff work had begun as early as 1924 on a document which finally saw the light of day in 1933 as SD 78, *Tables For Estimating Consumption and Wastage in War,* and in 1934 as SD 98, also entitled *Tables For Estimating Consumption and Wastage in War,* these were not firmed up until 1936, and then substantially gutted and reworked by 1941. However useful these tables were, they failed to deal with salvage and repair, or with the lessons of 1918, when there were very high casualties from operations, not all of which were lost over enemy lines.

Another difficulty was the High Command was not only deficient in its knowledge of modern production and the time needed to assemble raw materials and trained manpower for that activity, but it was also wanting in an understanding of what the technological and other revolutions were all about. Not only did aircraft, for instance, require far more parts and a greater knowledge of how to assemble and repair them, but also complexity had a multiplier that affected all operations as well as manufacturing.

Few people understood that a modern industrial war would require five years before war broke out, in addition to four years after it was declared, before wartime equilibrium would be reached. The latter was a short stage when everything was up and running not only militarily, but also bureaucratically, industrially, and the like.

During the Battle of Britain in 1940, the Inspector General of the RAF toured the available airfields. He found that the lowest serviceability rates were at Training Command stations where only 59% of the allocated 150 Spitfires and Hurricanes were serviceable. Why was the rate so low at a time of crisis? Basically, because either the fitters and riggers did not have tool kits or spares were not available, or both. At Fighter Command the serviceability rate was 75%, interestingly the same as for F-15s at Langley AFB, Virginia, some 45 years later. At Bomber Command the rate was 82%, except in the Number 2 Group where the Blenheims and Hudsons were at 106%. This was because the aircraft were not being used in the Battle of Britain and the ground crews had time to bring even the spare aircraft up to available status. (2)

Availability also had to do with the system of recording aircraft states (status). At 1700 hours daily the equipment officer had to call into headquarters the squadron's state:

(1) Aircraft currently available at dispersal.
(2) Aircraft which would be available by 0900 the next morning.
(3) Aircraft which would become available in 24 hours.
(4) Aircraft which could be repaired at the station in 34 days.
(5) Aircraft write-offs, meaning essentially that their repair was beyond local capability.

(Continued on bottom of page 26)

CURRENT RESEARCH

Rome Laboratory

The Electronics Reliability and Electronics System Engineering Divisions of the Rome Laboratory (RL) conduct focused research and development efforts in the area of reliability sciences. The basic objective of the reliability sciences thrust is to ensure Department of Defense (DOD) and Air Force electronic systems perform their specified mission in diverse military environments. This approach is based on a broad spectrum of science and engineering research that encompasses all aspects of the system life cycle from "cradle to grave." This research includes technology areas that stress development and use of tools and techniques such as modeling and simulation, materials and process characterization, operational assessments, failure modes and effects assessment, and correction. In addition, emphasis is placed on development of diagnostic techniques for implementation of cost effective logistic support capability such as strategies to support Two-Level Maintenance. This technology thrust is utilized by both the commercial and industrial base in the design, development, production, and maintenance of cost-effective, reliable systems that meet customer needs. If you have further interest or questions concerning the following efforts, please contact the respective program managers.

Computational Electromagnetics (CEM) for Reliable Command, Control, Communications, and Intelligence (C3I) System Design and Acquisition

DESCRIPTION: The need for systems to operate reliably in their intended electromagnetic environments is an integral part of the overall reliability equation. The Air Force need for CEM technology is in the area of design, development, testing, and insertion of large, active-phased arrays into C3I systems. Such arrays are used for the acquisition, tracking, and identification of small targets in the presence of clutter and secure communications.

Future technology development includes: design, development, and installation of a general-purpose CEM code on massively parallel processors; the refinement, enhancement, and validation of the existing formulations to satisfy the even greater demands for precision, resolution, and dynamic range required of future ultralow sidelobe arrays (ULSA) analyses; the development of an artificial intelligence (AI) capability to draw geometry data from existing aircraft manufacturer computer aided design/computer aided manufacturing (CAD/CAM) databases; the refinement of the electromagnetic (EM) modeling process; and data reduction and interpretation processes. This technology is very important to support test and logistics centers.

PAYOFF: The CEM technology program has provided critical design data to the air defense initiative for its concept studies, and to the Joint Surveillance Target Attack Radar System (JSTARS) program for its redesign of the ultrahigh frequency (UHF) ground and air communications systems. In the former case, several studies to quantify aircraft-generated pattern distortion of proposed ULSA have been conducted in-house to optimize operational capability, reduce on-board radio frequency coupling, and reduce cost by developing schemes to minimize the number of antenna elements needed to achieve specified beam patterns. The JSTARS data is being used by the program office in the redesign of future aircraft and the retrofit of existing aircraft.

(Kenneth R. Siarkiewicz, RL/ERST, DSN 587-2465)

Laser Mapper

DESCRIPTION: Rome Laboratory CEM research and development has developed the technology for computer-based tools to perform electromagnetic (EM) simulation of antenna and aircraft EM interaction, antenna patterns, and EM coupling more efficiently.

A laser range finder was integrated with a computer-controlled scanning mechanism to create a spherical coordinate system map of the object. The coordinate system is then converted to Cartesian coordinates (X, Y, Z), and the computer creates a single fitted map from the multiple views of the object. The map is then converted to a standardized CAD format suitable for CEM analysis.

PAYOFF: The laser mapper satisfies a need for a fast, efficient validation-enabling tool capable of rapidly, precisely, and accurately rendering EM range targets in a three-dimentional CAD model format. It allows CEM analysis of antenna performance for far less cost than is obtained from other methods.

(David O. Ross, RL/ERST, DSN 587-7624)

F-22 Aperture Measurement Program

DESCRIPTION: To reduce antenna development risk to the F-22 Advanced Tactical Fighter program, RL has established an F-22 airframe test bed to evaluate airframe effects on advanced aperture systems performance. A prototype YF-22 was modified to the engineering and manufacturing development (EMD) model 640 configuration at RL. The F-22 test bed is ready for measurements at the Newport Research Facility.

PAYOFF: Critical data will be provided two years prior to flight test and problems will be identified early on. The RL facilities and F-22 test bed provide a 100-fold increase in antenna measurement capability.

(Sigmund Grudzinski, RL/ERSE, DSN 587-7483)

AC-130H Gunship Enhanced AN/ALQ-172 Electronic Counter Measures (ECM) System

DESCRIPTION: This program was directed by the Warner-Robins Air Logistics Center for Air Force special operation forces. Older Air Force Special Operations Command AC-130H gunship electronic combat systems are being upgraded with ALQ-172s being removed from retired B-52s. These systems are

not just being moved to a different platform, but are being upgraded to meet today's threats. The installation of all the antennas are being optimized to provide maximum performance, which in turn provides increased survivability.

PAYOFF: Measurements performed at RL's Stockbridge Facility revealed installation related weaknesses, which were corrected prior to production and first flight. These included 14 major modifications to antenna installations and 9 major experiments with radar absorbing material, all prior to metal being cut on the flight test aircraft. For these problems to be revealed in a flight test program, a minimum of 23 sorties would have been required to identify all the problem areas identified by RL. Normally, enough profiles, specifically for antenna installation verification, would not have been flown due to the time and money constraints in a flight test program. These problems, in the normal course of events, would manifest themselves only after being in an operational environment for an extended period. One airborne pattern would require 2.7 hours of flight test time. The same pattern takes 15 minutes at RL's ground-based facilities and coverage above the aircraft as well as below is possible.

(Sigmund Grudzinski, RL/ERSE, DSN 587-7483)

Diminishing Manufacturer Sources

DESCRIPTION: Diminishing Manufacturer Sources (DMS) has plagued DOD systems for years. The problem is most acute in the microcircuit arena where there has been a recent announcement by several major semiconductor companies that they will no longer supply military grade parts. The underlying factor to this problem is that DOD systems are kept operational for 20 or more years, while the technology base which supplied the original devices is disappearing. Several years ago a semiconductor technology was readily available for 10-15 years. Today's military grade product turns over in about 7.5 years and, if the system relies on commercial grade devices, the technology becomes obsolete in about 5 years. Further compounding the problem is the introduction of low voltage devices. This new technology with supply voltages in the one to three volt range will be the dominant technology by the year 2000, replacing the five volt supply devices which are used in virtually all DOD systems.

PAYOFF: Rome Laboratory is addressing the DMS problem and is supporting major Air Force projects in their attempt to get a handle on the problem. Several approaches come to mind immediately: more robust designs; higher level of configuration control; proactive risk assessment program; and the use of very high speed integrated circuit (VHSIC) hardware descriptive languages (VHDL) to describe the microcircuit, board, or line replaceable unit (LRU). The best and most cost-effective way to address the problem is to recognize the impact of DMS on the system early-on in the design. A proactive risk assessment program is needed to accomplish this. By identifying those parts early-on which are susceptible to becoming a DMS candidate, a program manager can implement various strategies to assure parts will be available for the system build and that parts will be available as spares once the system is in the field. The risk assessment program needs to take into consideration several factors, such as the maturity of the technology used, the number of parts in the system, and the ability to reengineer or redesign the device. These factors will determine whether it is more cost effective to buy spares and store them or to redesign the board or system.

(Sigmund Grudzinski, RL/ERSE, DSN 587-7483)

Virtual Instruments for Testing and Failure Analysis

DESCRIPTION: The in-house microcircuit failure analysis lab at RL has taken a "first look" at where and how well simple virtual instrument (VI) tools might fit into the testing and analysis flow which accompanies microcircuit failure analysis. Graphical programming and virtual instrument software and hardware products are becoming widely used for a variety of testing and control applications which are portable across the common computer platforms. The user can construct special purpose instruments which consist of display screens, software control programs, hardware plug-in cards, general purpose instrumentation bus (GPIB) connected equipment, and external breadboard circuits. These new tools represent a significant departure from past approaches to bench testing.

Virtual instruments have been developed and used for both common and unusual electrical bench tests. They include: a simple two-terminal curve tracer; a transistor junction and beta family curve tracer; a multipin-to-supply curve tracer for pin-to-pin checking of microcircuits; a low frequency digital device truth table and power supply circuit test generator and tester; a low power mechanical relay tester; and an oxide test structure tester implementing a standard fast wafer-level current ramp test. These instruments all use the same base hardware consisting of a networked personal computer with two plug-in boards and a few GPIB boxes. In addition, they all produce spreadsheet data files, occupy the same 3 foot by 4 foot footprint situated next to a probe station, and represent a low initial investment.

PAYOFF: Virtual instrument-based tests may offer important advantages to the small and budget limited laboratory doing quick, first look failure analysis, and the test products are very portable. The use of VIs for testing will probably spread, and users should develop and share VIs found to be useful in these niche applications. Please contact us if you are interested in obtaining the above VIs for your use.

(Daniel J. Burns, RL/ERDR, DSN 587-2335)

Commercial Off-the-Shelf/Nondevelopment Item (COTS/NDI) Research

DESCRIPTION: Changes in the microelectronics industry and directives from the Office of the Secretary of Defense are rapidly impacting the way in which the system program offices (SPOs) must work. One of these changes is a push for the SPOs to use, in military applications, plastic encapsulated microcircuits (PEMs) designed and manufactured for commercial applications. There are certainly places for PEMs in military applications, but the questions we must answer are which applications and which PEMs?

Virtually all published data indicates the quality and reliability of PEMs have improved dramatically over the years. However, the data also indicates the quality and reliability of PEMs varies widely. These variations seem to be related to factors such as manufacturer, device type, package style, and application environment. Rome Laboratory is developing the knowledge and

tools the SPOs need to make wise decisions for their systems and for the DOD. The rallying cry "use best commercial practice" is only meaningful if the original equipment manufacturers (OEMs) know how to buy products which are suitable and cost effective for the DOD in the long run.

Wide variations have been found in "best commercial practice" manufacturing quality PEMs. All devices examined from two manufacturers showed a consistent difference in the level of manufacturing quality. When virgin parts of a mature PEM technology (14 lead dual in-line packages), produced by two well-known and widely respected "best commercial practice" manufacturers show such wide variations in manufacturing quality, it is a mistake to simply advise SPOs and OEMs to "buy commercial."

Voids and delaminations between the epoxy molding compound (EMC) and the lead frame, die paddle, and die, can lead to a host of problems that the user must consider. The most immediate problem is "popcorning" which can occur during rapid heating of the part (soldering) when liquid trapped within the part is vaporized. The rapid increase in volume stresses and often breaks the package and/or die. The package cracking can sound like popcorn popping. Delaminations along the lead frame can also act as entry points for contaminants into the package. Extrinsic contaminants such as a flux can be drawn in along the lead frame, greatly accelerating the corrosion rate within the package. Corrosion is further accelerated by using the product in a high humidity environment. Poor adhesion between the EMC and the die or lead frame means thermal stresses are borne to a greater extent by the wire bonds. In an environment where thermal excursions are frequent and involve very cold temperatures, shearing of the wire bonds is possible. This knowledge and much more is needed if the SPOs and OEMs are to consistently buy products which are suitable for their systems.

PAYOFF: Rome Laboratory is working on several efforts to provide more useful information for the SPOs and OEMs. Rome Laboratory's goal is to provide the SPOs and OEMs with the knowledge, guidance, and tools needed to answer the two critical questions: In which applications can PEMs be used and which PEMs are appropriate? The proper answer will assure project offices are smart buyers of best commercial practices.
(Daniel J. Burns, RL/ERDR, DSN 587-2335)

(Continued from page 23)

The aircraft write-offs were replaced from the local storage unit, but they dropped off the paper record. This explains why the graphs for aircraft in Fighter Command during the Battle of Britain show a steady decline of machines in the storage units, even though Spitfire and Hurricane production and losses were about equal.

Another way of looking at the matter of repairs was a study done by the Ministry of Aircraft Production. This study looked back on the war in terms of repaired aircraft as a percentage of total production. In May 1940, the figure stood at 13.5% of 1,298. By September it had risen to 37.6% of 1,906. In November 1940, of the 42.1% of repaired aircraft out of a total of 1,927 aircraft added to stocks, 300 were being repaired *in situ* (where they lay) and 512 were at works (returned to factories) for a total of 812, or more than all aircraft production in September 1939. By late 1942, the number of repaired aircraft available that month was the highest of the war, 53.9% of 3,179, or 1,714. The highest total number ever returned in one month was in June 1944, when 1,903 aircraft were added to production totals. (1)

What had made this possible was that, in addition to *in situ* teams, the RAF had managed to get its own repair and maintenance facilities. These facilities were originally envisaged as six (three civilian and three RAF), one million square-foot depots, with 10,000 men each.

Of course, the demands from expansion of the RAF put the RAF into competition with all the other technical services and industries for manpower. For the RAF, this was complicated by the prewar insistence that it took 7.5 years to train a fitter or rigger fully. Even when the frontline strength was pegged briefly at 750 aircraft, the RAF needed an intake of 1,000 fitters and riggers a year through Halton, the apprentice training establishment, but was only getting 200.

Summary

The RAF found itself saddled with six problems which could not be solved overnight:

(1) A lack of standardization.
(2) A lack of experience in spares ordering for wartime.
(3) A lack of planning for the repair of aircraft.
(4) A deficiency in the knowledge of modern production and a lack of understanding of the technological revolution.
(5) Low serviceability rates.
(6) A shortage of fitters and riggers.

It took the first four years of war to hammer out the balances and compromises necessary to run a fighting air force and make airpower effective.

References

1. Ministry of Air Production. AVIA 46/228, *Aircraft–The Spares Problem–Narrative*, London.
2. Office of Air Force History. *Air Superiority*, Washington DC: AFHSO/HO, 1995.

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Applying the Borda Ranking Method

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Beverly S. Woodward

Introduction

The following problem reoccurs in many different contexts within logistics: a finite number of criteria (attributes, objectives, scenarios, voters) are used to evaluate a finite number of alternatives (projects, candidates, options, items), with the goal of obtaining an overall ranking of the alternatives. As Cook and Seiford observed, ranking methods can be placed into two basic categories: cardinal methods and ordinal methods. (5) Cardinal methods require decision makers to express their degree of preference of one alternative over another for each criterion; they include multiple attribute utility theory (MAUT) and the analytic hierarchy process (AHP). (9,11) On the other hand, ordinal methods require only that the rank order of the alternatives be known for each criterion.

Many ordinal ranking methods have been devised during the past two centuries. These methods fall into several categories including voting, mathematical programming, and outranking techniques. (1,2,6,8,10) Borda's voting method is conceptually simple and is perhaps the easiest ordinal method to implement. (3) In this article, we first describe the Borda method and then show how we used it to study the maintenance drivers for the Airborne Warning and Control System (AWACS).

Borda's Voting Method

Borda proposed the following voting method in 1770. (3) Given N candidates and multiple voters, points of $N - 1$, $N - 2$, . . ., and 0 are assigned to the first-ranked, second-ranked, . . . , and last-ranked candidate in each voter's preference order. The points for each candidate are summed across all voters, and the winning candidate is the one with the greatest total number of points.

Instead of voters, suppose there are multiple criteria. If we think of each criterion as being a voter and if r_{ik} is the rank of alternative i under criterion k, the Borda count for alternative i is:

$$b_i = \sum_k (N - r_{ik}).$$

Equation 1

The alternatives are then ordered according to these counts.

Borda's method is an example of a *positional voting method*, which assigns P_j points to a voter's *jth*-ranked candidate, $j = 1$, . . . , N, and then determines the ranking of the candidates by evaluating the total number of points assigned to each of them. Voting theorists have shown that Borda's method is the optimal positional voting method with respect to several standards, such as minimizing the number and kinds of voting paradoxes. (7,10,12) In addition, if ties are not present in the criteria rankings, Cook and Seiford demonstrated that Borda's method is equivalent to determining the consensus ranking that minimizes the sum of the squared deviations from each criterion ranking. (4)

Borda Method Example

Background

The Air Force's Electronic Systems Center (ESC) is currently implementing a modernization program to extend the life of the E-3 AWACS. The primary focus of this program, known as Extend Sentry, is to increase the availability of operational aircraft to perform the AWACS mission. The program goal is to increase mission capable rates from 85 to 90%. To accomplish this goal, both abort and break rates must be significantly improved and aircraft downtime resulting from maintenance problems must be reduced.

AWACS is considered to be a viable system that will operate well into the next century, and it continues to support tasking directed from the Joint Chiefs of Staff with a demand exceeding present capability. Although the fleet is, on average, nearing the midpoint of the 30,000 hour airframe life, many of the on-board systems are at the end of their projected service lives. Extend Sentry will provide the needed investments to update or replace these aging systems. More than 100 candidate projects are being evaluated.

Maintenance Study

The AWACS Program Office requested an analysis of maintenance drivers for the surveillance radar system. The Borda method provided a consistent framework for determining the ranking of the maintenance drivers and for selecting candidate projects. In addition, the Borda method identified top maintenance drivers not addressed by the candidate projects. Further studies could be undertaken to investigate solutions for these top drivers.

The Program Office identified seven maintenance criteria that needed to be examined:

(1) On-Equipment Hours - number of scheduled and unscheduled maintenance hours performed on the aircraft at the flying wing.

(2) On-Equipment Events - number of scheduled and unscheduled maintenance actions on the aircraft at the flying wing.

(3) Total Maintenance Hours - number of on-equipment and off-equipment maintenance hours performed at the flying wing.

(4) Total Depot Charges - moneys paid for repair of items that are part of the depot reparable stock fund; for serviceable assets, refers to the exchange price, which includes the average depot repair cost and the fund's surcharge.

(5) Cannot Duplicates (CNDs) - number of problem reports that cannot be repeated onboard the aircraft.

(6) Aborts - number of failures that result in the mission being halted; includes both before-flight and in-flight aborts.

(7) Code 3 Breaks - number of occurrences when system performance was deemed unsatisfactory. Comparisons with specification levels determine if the aircraft may be used for further missions.

Maintenance data for these seven criteria were collected from several sources for more than 300 radar surveillance line replaceable units (LRUs) and shop replaceable units (SRUs). Each LRU and SRU was identified by a specific work unit code (WUC). Data were provided for fiscal year 1992 (FY92), FY93, and FY94. This data was used to rank the WUCs with respect to each of the seven maintenance criteria, for example, the WUCs with the highest numbers to lowest number of on-equipment hours, the WUCs with the highest to lowest number of on-equipment events, etc. Next, by using the Borda method, a composite ranking (which aggregates the criteria rankings) was obtained for each fiscal year, and then a composite ranking across the three fiscal years was determined.

Implementing the Borda Method

To illustrate Borda's method, a simplified example is provided below. Table 1 shows data for five WUCs, and Table 2 provides the corresponding rankings for each of the seven maintenance criteria. For each criterion, a ranking of 1 is assigned to the highest-placed WUC, a ranking of 2 is assigned to the second-placed WUC, and so forth. For example, for on-equipment hours, a ranking of 1 is assigned to WUC 5 in Table 2, since the largest number of hours is listed for this radar item in Table 1.

Table 1 shows there are cases in which the data are the same for two or more WUCs. Such ties are generally handled by averaging the associated rankings. For instance, WUCs 1, 3, 4, and 5 are tied for second through fifth place for aborts. The average of the rankings (2, 3, 4 and 5) is 3.5, which is the entry appearing in Table 2.

For each of the seven maintenance criteria, Table 3 provides the Borda points assigned to each WUC. Because there are five WUCs in this example, four (5 - 1) points are assigned to the first-ranked WUC for each criterion, three (5 - 2) points are assigned to the second-ranked WUC, and 0 (5 - 5) points are assigned to the last-ranked WUC. These Borda points are then summed across the seven criteria, yielding the Borda counts in Table 4. WUC 5 is the top maintenance driver since it has the highest Borda count, namely 23.5. These Borda counts yield the preference order of WUC 5, WUC 2, WUC 4, WUC 3, and WUC 1.

Conclusions

The Borda method is a relatively simple positional voting method that determines the ranking of the candidates by evaluating the total number of points assigned to each one. The method is easy to implement and has the added feature of being able to assign weights to the alternative criteria. The data used to determine rankings must be carefully examined, particularly in the instances where there are several "ties." The Borda method provided a consistent framework for evaluating multiple categories of maintenance data for the many items addressed in the AWACS investigation.

When compared with cardinal ranking methods, the Borda method offers the following advantages:

(1) It minimizes the need for subjective assessments. In contrast, subjective assessments are generally needed to construct utility functions in multiple attribute utility theory and to make pairwise comparisons in the analytic hierarchy process.

(2) The Borda method does not require the criteria to satisfy independence conditions. In contrast, an additive utility representation requires the critieria to display what Keeney and

WORK UNIT CODE	NAME	ON-EQUIPMENT HOURS	ON-EQUIPMENT EVENTS	TOTAL WING MAINTENANCE HOURS	DEPOT CHARGES (1,000s $)	CANNOT DUPLICATES	ABORTS	BREAKS
81AAA	WUC1	272	26	318	113	5	1	1
81BBB	WUC2	817	56	821	420	10	2	4
81CCC	WUC3	544	59	650	334	3	1	2
81DDD	WUC4	286	25	1,041	1,387	4	1	1
81EEE	WUC5	1,162	84	1,416	588	11	1	3

Table 1. Maintenance Data for Surveillance Radar System Work Unit Codes (WUCs)

WORK UNIT CODE	NAME	ON-EQUIPMENT HOURS	ON-EQUIPMENT EVENTS	TOTAL WING MAINTENANCE HOURS	DEPOT CHARGES (1,000s $)	CANNOT DUPLICATES	ABORTS	BREAKS
81AAA	WUC1	5	4	5	5	3	3.5	4.5
81BBB	WUC2	2	3	3	3	2	1	1
81CCC	WUC3	3	2	4	4	5	3.5	3
81DDD	WUC4	4	5	2	1	4	3.5	4.5
81EEE	WUC5	1	1	1	2	1	3.5	2

Table 2. Rankings of Work Unit Codes (WUCs) by Maintenance Criterion

WORK UNIT CODE	NAME	ON-EQUIPMENT HOURS	ON-EQUIPMENT EVENTS	TOTAL WING MAINTENANCE HOURS	DEPOT CHARGES (1,000s $)	CANNOT DUPLICATES	ABORTS	BREAKS
81AAA	WUC1	0	1	0	0	2	1.5	0.5
81BBB	WUC2	3	2	2	2	3	4	4
81CCC	WUC3	2	3	1	1	0	1.5	2
81DDD	WUC4	1	0	3	4	1	1.5	0.5
81EEE	WUC5	4	4	4	3	4	1.5	3

Table 3. Borda Points Assigned to Work Unit Codes (WUCs)

WORK UNIT CODE	NAME	POINT COUNT
81AAA	WUC1	5
81BBB	WUC2	20
81CCC	WUC3	10.5
81DDD	WUC4	11
81EEE	WUC5	23.5

Table 4. Borda Point Counts for Work Unit Codes (WUCs)

Raiffa call "mutual preferential independence," which may not hold in practice. (3)

(3) The Borda method needs only enough precision in data to determine a rank order for each criterion. In contrast, cardinal methods require additional precision to determine the degree of preference of one alternative over another.

References

1. Arrow, K. J., and Raynaud, H. *Social Choice and Multicriterion Decision-Making*, Cambridge: The MIT Press, 1986.
2. Black, D. *The Theory of Committees and Elections*, Boston: Kluwer Academic Publishers, 1987.
3. Borda, J-C. "Mémoire sur les Élections au Scrutin," *Histoire de l' Académie Royale des Sciences*, Paris, 1781.
4. Cook, W. D., and Seiford, L. M. "Borda-Kendall Consensus Method for Priority Ranking Problems," *Management Science*, 28, 1982, pp. 621-637.
5. Cook, W. D., and Seiford, L. M. "Priority Ranking and Consensus Formation," *Management Science*, 24, 1978, pp. 1721-1732.
6. Fishburn, P. C. "Condorcet Social Choice Functions," *SIAM Journal of Applied Mathematics*, 33, 1977, pp. 469-489.
7. Fishburn, P. C., and Gehrlein, W. V. "Borda's Rule, Positional Voting, and Condorcet's Simple Majority Principle," *Public Choice*, 28, 1976, pp. 79-88.
8. Hwang, C. L., and Lin, M. J. *Group Decision Making under Multiple Criteria*, New York: Springer-Verlag, 1987.
9. Keeney, R. L., and Raiffa, H. *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, New York: Wiley, 1976.
10. Saari, D. G. *Geometry of Voting*, New York: Springer-Verlag, 1994.
11. Saaty, T. L. *The Analytic Hierarchy Process*, New York: McGraw-Hill, 1980.
12. Van Newenhizen, J. "The Borda method is most likely to respect the Condorcet principle," *Economic Theory*, 2, 1992, pp. 69-83.

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Best Article Written by a Junior Officer

The Executive Board of the Society of Logistics Engineers (SOLE) Chapter, Montgomery, Alabama, has selected "Activity Based Costing: Applications in Military and Business Logistics" (Winter 1995), written by Captains Robert W. Callahan, USAF, and Daniel A. Marion, Jr., USAF, in collaboration with Major Terrance L. Pohlen, USAF, as the best *Air Force Journal of Logistics* article written by a junior officer(s) for FY95.

Will the Consumable Item Transfer Affect Support for Air Force Weapons Systems?

Captain Charles E. Deckett, USAF

Background

The Consumable Item Transfer (CIT) program originated with the approval of Defense Management Report Decision (DMRD) 926 on 3 July 1990. DMRD 926 was the Inventory Control Point Consolidation Study Report which recommended transferring the inventory control point for many Service-managed consumable items to the Defense Logistics Agency (DLA). The Services were asked to provide input on this decision via questionnaire. The Air Force response for Phase II of the program, the current phase, came out of the USAF Director of Supply's office in January 1993. The Director's inputs were considered, and the program put into effect. That is, item management for the majority of Air Force-managed consumable items has been, or is in the process of being, transferred to DLA.

Effect on Support

Should we expect support to suffer because of this? On the surface, *no*. In fact, just looking at the generally accepted track record of support from DLA, we might even expect support to improve. Over the years we have been accustomed to getting about 5% better parts support on DLA-managed consumable items versus those managed by Air Force Materiel Command (AFMC). This means we are used to DLA having the items we order in stock 5% more of the time than do the Air Force depots. Granted, there are many reasons for this. Not the least of which is the type of items managed, but still, we should at least expect support to remain at about the same level once item management has transferred.

Why then is there the perception among many Air Force consumable item customers we are getting worse support from DLA on the items we have transferred so far? We probably contributed to the decline in support by our own Air Force inventory management practices leading up to, and throughout, the CIT process. Essentially we have let the pipelines run out and the shelves become bare as we have prepared to transfer item management on many items to DLA. It is also likely that we have transferred inaccurate demand data to DLA on many of the items.

These things were not done to spite DLA. Unfortunately, our Air Force item managers were faced with very limited funding throughout the period of planning and implementation of CIT. According to the Air Force CIT representative to DLA, consumable items were known to be funded at only 65% leading up to, and through, Phase I of the transfer process. This resulted in less than 100% support of requirements. Hard decisions concerning what to buy and what not to buy had to be made by our item managers. It is likely they decided to buy more of those consumable items they knew they were going to continue to manage than those they knew were about to transfer to DLA. You can see how this led to the pipelines drying up. Of course, as the requirements from the field continued, but the assets coming in to the Air Force Depots did not, the quantities in stock diminished.

So, limited funding may have led to transferring item management to DLA on items with empty pipelines and shelves, but where does transferring inaccurate data enter the equation? Decisions on what to stock and how much to stock at the wholesale level are driven by data accumulated as users at the retail level, and repair actions at the wholesale level generate requirements. This is an automated process, and there are numerous opportunities in this process for the data to be skewed because of inconsistency of demands, improper entry of demands, and improper coding of any of the multiple data elements involved in these equations. It is likely, because of these factors, we had inaccurate data for our Air Force item managers, too. One thing our item managers had, that DLA item managers accepting responsibility for newly managed items will not have, is enough experience with these particular items to make stockage decisions based on other than the automated data generated. Further complicating the issue of transferring accurate data to DLA was the fact there were problems with the AFMC and DLA systems interfacing during Phase I. According the Air Force CIT Office, there were data inaccuracies on more than 50% of the items transferred in Phase I.

Recovery Timeline

Accepting we may have put ourselves in the position of getting worse support from DLA than we expected when the same consumable items were managed within the Air Force, when will it get better? In the worst case, that there is no stock on-hand, there is nothing in the pipeline, and we transferred no demand data, it could take up to two years. TWO YEARS! Yes, that is a long time, but this is worst case. It will probably take at least three to six months, two quarters, for demand data from the retail user's and wholesale repair requirements to generate a decision to stock the items at DLA. Then it may take another three to six months, or more, to actually find a source and establish the delivery schedule. This is just to begin to fill the pipeline. In some cases, the pipeline, or lead time, may be up to a year long. That is two years to stock some items we may have recently had on the Air Force's shelves. DLA will certainly act to fill high priority requirements from the field as they are generated, but it will take time to build a stock level so assets can be issued rather than have to be back ordered.

(Continued on bottom of page 36)

Advanced Study of Air Mobility (ASAM)

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Introduction

Air Mobility Command's (AMC's) Air Mobility Warfare Center (AMWC) and the Air Force Institute of Technology's (AFIT's) Graduate School of Logistics and Acquisition Management have formed a joint venture to produce an in-depth program focusing on the Global Reach concept. The program employs a wide variety of course and education techniques to expose a limited number of rated and nonrated support officers to the latest practices and theory underlying mobility operations. Students attending the Advanced Study of Air Mobility (ASAM) program are board-selected by senior AMC leadership based on accomplishments, academic performance, and leadership potential. ASAM graduates receive a Master of Air Mobility degree and a prefix to their Air Force Specialty Code (AFSC) denoting special expertise in air mobility. The ultimate goal of the ASAM program is to cultivate a core of mobility experts to lead AMC into the future. The unique combination of graduate and continuing education courses, AMWC and AFIT faculty, mobility focus, and student backgrounds provides a tremendous opportunity for officers interested in an in-depth study of mobility operations.

Background

The changing security arrangement caused by the end of the Cold War has produced new missions, including peacekeeping and humanitarian assistance that were outside the regions previously considered by military planners. AMC has especially played a significant role in supporting these evolving military operations. Because the prospect of these missions continuing into the future appears very likely, Air Force leaders feel officers will require additional education to be able to plan and implement such military operations.

General Ronald R. Fogelman originally proposed the concept which resulted in the formation of the ASAM program. While serving as Commander, United States Transportation Command (USTRANSCOM), and Commander, Air Mobility Command, he identified the need to tie tanker and airlift missions together to support mobility operations. (1) The combination of these missions, a changing world environment, and a Global Reach strategy, requires future leaders to possess a thorough knowledge of how to best plan and employ air mobility forces.

The AMWC had the task of developing the concept into an ongoing program for air mobility officers. The AMWC staff was already offering courses in mission planning, combat tactics, and directing mobility forces; however, they did not have the faculty or accreditation to offer a masters degree in mobility operations to serve as a foundation for the ASAM program. Consequently, AMC and AMWC sought the assistance of AFIT's Graduate School of Logistics and Acquisition Management (AFIT/LA) to create an accredited masters degree program tailored to meet their specific needs.

The Advanced Study of Air Mobility Program

Collaboration between AFIT/LA and AMWC resulted in the ASAM program. The 13-month program consists of three distinct parts: an accredited Master of Air Mobility degree, an AMWC core of mobility courses, and an on-site study of mobility applications within the Department of Defense (DOD) and industry.

Master of Air Mobility Degree

The Master of Air Mobility degree provides the theoretical foundation for the ASAM program. The curriculum is fully accredited and taught by the AFIT/LA faculty. The degree is largely comprised of logistics and transportation courses, with an emphasis on mobility applications. The program consists of 13 three- and four-credit hour courses and a graduate research paper examining some aspect of mobility operations. The courses in the program include:

- Logistics Management.
- Principles of Transportation.
- Federal Financial Management.
- Statistics for Managers.
- Forecasting Management.
- Logistics Models.
- Quantitative Decision Making.
- Maintenance and Production Management.
- Transportation Management.
- Seminar in National Security Policy.
- Contracting and Acquisition Management.
- Management and Behavior in Organizations.
- Transportation Policy and Strategic Mobility.

The Master of Air Mobility program required an innovative approach to offering a masters degree since the students reside at Fort Dix, New Jersey, while the AFIT faculty is at Wright-Patterson AFB, Ohio. As a result, the curriculum adopted several techniques for course delivery.

Ten of the thirteen courses employ a condensed eight-day format. A class meets for four hours a day with readings, cases, and projects. The remainder of the day is used for homework completion. The students only take one class at a time under this format. Even with the time compression and significant amount

of prior preparation and evening study, the ASAM students have generally preferred this format.

Due to course content, the remaining three courses are taken in a single traditional 10-week quarter; however, the courses are taught by distance education via satellite transmissions from AFIT to Fort Dix. The courses taught in the quarter format include: Forecasting Management, Quantitative Decision Making, and Logistics Models. For the first two weeks of the quarter the students go temporary duty (TDY) to AFIT to become familiar with their instructors, research their graduate research paper topic, and identify advisors and committee members for their research papers.

The ASAM students use the graduate research paper to perform an in-depth examination of some problem or issue confronting the air mobility community. Students choose their own topic and work with an AMWC and an AFIT advisor. The AMWC advisor provides the functional expertise in air mobility, while the AFIT advisor concentrates on the logistical aspects of mobility operations. Research paper topics have included aeromedical evacuation, military operations other than war, intransit visibility, intermodalism, AMC's air reserve component mix, and the role of the Director of Mobility Forces.

Air Mobility Warfare Center Courses

The ASAM students receive their instruction in air mobility operations from the AMWC staff at Fort Dix. Four courses comprise the AMWC portion of the ASAM program. The Air Mobility Operations Course provides mid-level mobility managers with the big picture of AMC's air mobility system. The Directors of Air Mobility Forces seminar is for senior officers preparing to become field directors of mobility forces. The students also learn about mission planning and combat tactics for tankers and airlifters in the AMWC Planners and AMWC Tactics courses. McGuire AFB is adjacent to Fort Dix, and its proximity to AMWC allows the students to observe first-hand how an air mobility wing operates, the issues affecting mobility operations, and management innovations as they occur. The ASAM students take these courses between their AFIT masters classes.

Site Visits

Site visits complement the AFIT and AMWC coursework. Students have the opportunity to travel to several overseas and continental United States (CONUS) locations to observe the Global Reach concept in action. Classes have studied allied tanker and airlift operations in the 38th Group, Royal Air Force; theater operations at Supreme Headquarters Allied Powers Europe (SHAPE); air mobility operations with the 621st Air Mobility Support Group, Ramstein Air Base, Germany; and joint mobility operations at Military Traffic Management Command (MTMC) and Military Sealift Command (MSC). Visits to leading industrial firms such as Boeing, Microsoft, CSX Corporation, and Emery Air Freight serve as a conduit for transferring applicable commercial practices into air mobility. The students also learn about media relations in a seminar with major New York-based press outlets. The site visits offer an experience beyond the strictly academic and technical to provide the students with a wide-ranging tool set for managing air mobility forces.

Initial ASAM Success

The ASAM program has proven very successful. The program recently graduated its first class, and faculty and student reactions to the program have been highly favorable.

Initially, concerns surfaced regarding whether the compressed format would permit the same coverage of material and whether the ASAM students could achieve the same level of performance as students in a traditional in-residence program. The program overcame these concerns through several planned as well as unanticipated results. First, the four-hour-per-day class schedule actually provided more contact time between the students and instructor than normally occurs in a 10-week quarter. The students experience less distraction since they can concentrate on studying for one class at a time. Second, the courses requiring extensive student preparation were placed in the single 10-week quarter. The students were provided more time to assimilate the material in these courses due to the level of difficulty and quantitative material. Third, significant preparation went into developing and scheduling course materials to make the maximum use of available time. Finally, technology has played a major role in supporting the program and overcoming the distance problem. E-mail is frequently used to communicate between faculty and students. File transfer protocol (FTP) has enabled students and faculty to exchange papers, tests, and course readings. Satellite classes have also been demonstrated as a successful delivery mechanism for graduate courses. Satellite transmissions typically rely heavily on computer-based presentations and have actually increased the amount of technology applied in the classroom.

The students produced the unanticipated results contributing most to the success of the ASAM program. The board selection process yielded classes of highly motivated rated and nonrated logistics officers. As a result, the students generally had read and studied most of the course material prior to the first day of class. The students study an extraordinary proportion of their available time and frequently work together as a class or in study groups. On-site, TDY faculty were also available to the students during nonclass time, including evenings and weekends. The situation provided more opportunities than originally anticipated to discuss and reinforce the material outside the classroom. The students' 9 to 13 years work experience also proved a significant factor in their performance. They have been able to relate much of their experience directly to the AFIT and AMWC course work and are able to apply the concepts to real-world problems.

ASAM Students

The ASAM program has resulted in three classes of 10, 16, and 12 students. The first class began course work in April 1995 and graduated in May 1996. The second and third classes are currently in session with graduations projected for December 1996 and May 1997. Rated officers (pilots and navigators) comprise the majority of officers attending the program. However, each class has included two nonrated logistics officers with experience in communications, aerial port operations, or aircraft maintenance. Air National Guard and Air Force Reserve students have also been selected for the program. The diverse backgrounds allow the students to

discuss and examine the entire spectrum of functions required to support air mobility operations. Upon graduation, the Air Force will channel the ASAM graduates into selectively identified assignments to use their special expertise. These officers are considered highly competitive for squadron, group, or wing commands. Graduates from the first class have received assignments to Headquarters, USTRANSCOM; Headquarters, USAF; and Headquarters, AMC.

Student Selection

AMC will select 14 officers for the fourth ASAM class in November. The annual year 1997 (AY97) selection board will convene at Scott AFB, Illinois, on 19-20 November 1996. Classes begin on 4 June 1997 and end 3 July 1998.

Eligibility Requirements

The eligibility requirements for the ASAM program include:

- Support and rated officers with between 9 and 13 years of commissioned service.
- Applicants must have experience in supporting mobility operations.
- Non-AMC officers with previous rated experience in a mobility weapon system (C-130, KC-10, etc.).
- Rated officers must be an instructor or prior instructor in a mobility aircraft (KC-135, CK-10, C-5, C-17, C-141, C-9, C-21, C-135, or C-130).
- Not deferred major and not have applied for retirement or separation.
- Undergraduate grade point average (GPA) of 3.0 and a combined Graduate Record Examination (GRE) score (verbal and quantitative) of 1100 or a Graduate Management Admission Test (GMAT) score of 550.
- Candidates must forward their official college transcripts (with seal) and GRE or GMAT scores to AFIT/RRE, 2950 P Street, Wright-Patterson AFB, OH 45433-7765, before the board meets. All candidates will be reviewed by AFIT prior to final selection.
- The GMAT national test date is in October which does not allow scores to be posted at AFIT prior to the AY97 board. Officers should plan on taking the GRE and ensure the test results are sent to AFIT (if they have not previously taken the GRE). Candidates who have previously taken the GRE or GMAT must ensure that AFIT has the test results on file.
- Candidates not meeting the undergraduate GPA requirement, but possessing an acceptable GRE or GMAT score, will be reviewed on a case-by-case basis by AFIT and AMWC for entry into the program.
- Individuals with less than 36 months time-on-station will be handled on a case-by-case basis by the Air Force Personnel Center (AFPC).

Selection Process

Application procedures can be obtained from the officer's major command's personnel directorate (MAJCOM/DP). Applicants applying for the ASAM program must complete a board-specific Air Force Form 3849, PME/AFIT/RTFB Officer Worksheet, and obtain endorsements by their staff director, numbered air force commander, wing commander, or wing commander equivalent. The Air Force (AF) Form 3489 should indicate "Student, Advanced Study of Air Mobility" in Part II. The last line of the Part III remarks will include undergraduate GPA, masters GPA (if applicable), and GRE or GMAT score. The endorsing official may make remarks in Part IV. The endorsing official, by signing the AF Form 3489, certifies the nomination and release of the candidate for permanent change of station (PCS) and any prerequisite training required by AMWC. The AF Form 3489 should be forwarded through the MAJCOM/DP. The board specific AF Form 3489 and a copy of the officer's command personnel records (non-AMC candidates) are then forwarded to HQ AMC/DPAD. Points of contact regarding the submission process are Captain Steve Parker, AMWC/WCOA, DSN 944-4401, and Major Steve West and MSgt Mazzuca, HQ AMC/DPAD, DSN 576-5729.

Conclusion

ASAM offers a unique opportunity for nonrated and rated officers desiring to pursue an in-depth study of air mobility in an operational setting. The partnership between the AMWC and AFIT has resulted in a highly innovative program by combining the unique talents, educational backgrounds, experiences, and resources of both institutions. By exposing these officers to the logistical and operational aspects of air mobility, the ASAM program provides the expertise needed for adapting and responding to the Air Force's evolving mobility mission.

References

1. Air Mobility Warfare Center. "What is ASAM?" Fort Dix, NJ: AMWC/WCOA, undated.

Major Pohlen is presently an Assistant Professor of Logistics Management and Lieutenant Colonel Simons is an Associate Professor of Logistics Management at the Air Force Institute of Technology's Graduate School of Logistics and Acquisition Management, Wright-Patterson AFB, Ohio. Doctors Cunningham and Brandt are also Associate Professors of Logistics Management at the Graduate School of Logistics and Acquisition Management.

Career and Personnel Information

Logistics Professional Development

The Promotable Jobs

After two years of working assignments and observing promotion board results, I have compiled a list of the most promotable logistics jobs. Here is the list:

- The job you are in right now.

That is it. The most promotable job is the one the Air Force and your boss have given you to do now. I have seen officers promoted while at wing-level, major command, numbered air force, field operating agency, the Pentagon, joint duty, special duty, logistics career broadening, logistics cross flow, wholesale level, and operational level, with a "definitely promote" or a "promote" recommendation.

So what is the qualifier? Those performance reports and awards, written and signed by your rater and senior rater, tell the promotion board all they need to know to determine what kind of officer you have been, are, and therefore, what your potential might be. Believe me, it is not the duty title, Air Force Specialty Code, or position number the board members zoom in on. It is how you are doing your job. Are you proactive or reactive? Do you work to improve processes or settle for the status quo? Do you drive or lead? Has the commander entrusted you with the "tough" jobs? Are you completing required training? What recommendation is your senior rater making for your future in the Air Force based on what you are doing now? You are actually building a reputation with senior leaders through the impression you leave with your current chain of command. Sure, it is best to show an increase in the level of responsibility from one assignment to another. But, the needs of the Air Force and the assignment system do not always make that possible. All you have to fall back on is your reputation.

When you have the leeway to "shop" for your next job, we at the Air Force Personnel Center can offer a lot of counsel and advice on what the next logical career move for you might be. However, your commander has the experience and is in a better position to tell you how you are doing your current job and what career path would be best for you based on your potential.

So, next time you ask, "where are the promotable jobs?" look around, you are probably there!

(Capt Craig A. Bond, HQ AFPC/DPASL, DSN 487-6417)

Improved Officer and Enlisted Assignment System

The Air Force is continually working to improve its enlisted and officer assignment procedures. The most recent improvement will enhance assignment opportunities for Air Force members, provide stability for all, and allow the Service to fulfill its mission.

One change will impact unaccompanied, short tour assignments. The Air Force will provide a 100% opportunity for enlisted members and company grade officers to request a follow-on assignment before going on a short tour. This means they can request bases or areas prior to their departure for the short tour. Members may request a base, a geographical area, or a state. Based on the needs of the Air Force, the Air Force Personnel Center (AFPC) will match them to those bases or areas. In some cases, the specific job they will do at their follow-on location will be determined later. For example, an officer may choose "San Antonio," and if approved based on the needs of the Air Force, that individual will be assigned to a specific base in that area (Brooks, Kelly, Randolph, etc.). The location would be "locked" based on overall manning projections, but the specific job they would do would be determined later. This same opportunity will be extended to field grade officers to the maximum extent possible. More Air Force members will now know where they are going after their short tour and can make future plans accordingly, allowing for more family stability. It will also allow them to concentrate on their jobs while they are on the short tour without having to worry about their follow-on assignments. The Air Force is able to do this now because it is a much smaller force after the drawdown. In the mid-1980s, about 35,000 people a year completed short tours—now the figure is approximately 11,000. This new improvement will take better care of all our enlisted members and company grade officers, and their families, as they prepare to serve unaccompanied short tours.

Another change concerns the way officers are selected for jobs. Currently, jobs are advertised and a "best match" is made by AFPC for a position. At that time, the losing commander provides inputs on the officer's qualifications and availability for the job. In the near future, commanders will be able to provide inputs on their officers' next assignments even before they enter the assignment cycle. Commanders will also be able to provide in-system inputs to AFPC assignment managers on what jobs their officers should do next. The information will be kept on file until the officers are selected for assignment or the commanders update their inputs.

A change will also being made at the gaining commander's end of the process. Instead of commanders (or hiring authorities) receiving only the names AFPC determines to be the best match for the job, the commander will get a list of all eligible and qualified volunteers. To facilitate the decision-making process, the commander has been given worldwide access, via the military personnel flight, to the same information AFPC uses to determine the best person for a job. The commander will be able

to review such items as duty history and professional military education (PME) completion on each person who volunteered. Members coming from short and other overseas assignments, completing school, or finishing controlled tours will still have priority.

Finally, the Air Force is going to provide jobs earlier for officers completing in-residence PME. The personnel center's goal is to have all school graduates an assignment at least four months prior to graduation. This was not possible before because selection boards, such as the return to fly board and professional military education designation boards, were held too late in the assignment cycle to make this a reality. To achieve the new goal, Intermediate Service School and Senior Service School selection boards will be standardized to convene in October, with other pertinent boards also moved up whenever possible. Early boards will allow for more advanced projections of available jobs PME students might fill. This change will help the student officers and their families plan their next move better.

The main goals of these assignment system changes are to ensure commanders have the right people in the right jobs to accomplish the Air Force mission and to provide the military members and their families with more voice in their futures as well as more stability. The Air Force Personnel Center will continue to review and improve the assignment system.

(Capt Pete Ellis, HQ AFPC/DPAIP4, DSN 487-4098)

New Joint Logistics Assignment Course

Imagine you are a major or lieutenant colonel, or civilian equivalent, who just received orders for assignment to an organization dealing with logistics at the joint level. Sure, you have years of experience doing logistics the "Air Force way," but how are you going to know what to do now that you are "joint?"

You are not alone in feeling less than prepared for the world of joint logistics. As a matter of fact, the Joint Logistics Commanders (Commander, Air Force Materiel Command (AFMC); Commander, Army Materiel Command (AMC); Deputy Chief of Naval Operations (Logistics); Marine Corps Deputy Chief of Staff, Installations and Logistics; and the Director, Defense Logistics Agency (DLA)) decided in 1991 that a void existed in the education of mid-level executives.

To remedy this, the Joint Course on Logistics (JCL) was designed to prepare these individuals for assignments involving joint logistics planning, interservice and multinational logistics support, and joint logistics in a theater of operations. Prospective students are those that are in, or soon will be in, positions requiring joint logistics knowledge. These include positions on the staffs of the Joint Chiefs, Department of Defense (DOD), headquarters of the military departments or the Defense Logistics Agency, unified commands and major logistics commands. The course is also designed for project or program managers, staff officers working on doctrinal issues, and reserve component officers working in positions equivalent to any of those described above.

The objectives of the JCL are to:

- Integrate DOD and Service programs to provide effective, economical logistic support to national strategic priorities and objectives, and to establish the basis for resource decisions.
- Compare and contrast the similarities and differences within DLA and the Services in applying theory, defining processes, and developing logistical support of joint, departmental, and theater objectives.
- Describe how DLA and the Services project logistics capability to support the combatant commands.
- Integrate multinational (combined) logistics as a multiplier of joint logistics support.
- Develop a plan as a member of a theater staff for using Service component logistics resources to support theater contingency operations.
- Assess the effects of defense and Service strategy and continental United States (CONUS) sustainment capabilities on logistical support decisions.
- Apply the Services' and DLA's logistics support capabilities in a developing contingency scenario.

The course length is 13 class days and is conducted at the Army Logistics Management College (ALMC), Fort Lee, Virginia. Quotas have been distributed to the Services, and if you are interested in attending, the course number is ALMC-JC, with the first class starting 1 October 1996. See your training officer or NCO for more information on how to apply for one of the Air Force quotas.

(Lt Col Don Murvin, ATSZ-LSL(LSL), DSN 539-4117, murvind@lee-dns1.army.mil)

Air Force Institute of Technology (AFIT) Opportunities

The Air Force Institute of Technology (AFIT) offers a masters degree in several logistic disciplines. This requires a 15-month permanent change of station (PCS) assignment to Wright-Patterson AFB, Ohio. Officers selected for this highly-competitive program will receive follow-on assignments to positions requiring advanced academic degrees. Officers interested in applying for AFIT should contact their education office to request an AFIT review of their eligibility. Officers volunteer for the AFIT assignment through the Electronic Bulletin Board. After AFIT determines eligibility, officers are competitively selected for the AFIT assignment by AFIT and the Air Force Personnel Center (AFPC). Minimum prerequisites for AFIT are a 3.0 undergraduate grade point average, a minimum of 500 verbal and 600 quantitative on the Graduate Record Examination (GRE), and 2 years time-on-station.

(Capt Ken Backes, HQ AFPC/DPASL, DSN 487-4024)

Cross Flow Program Alive and Well

The Air Force Personnel Center (AFPC) Logistics Branch continues to aggressively work cross flow assignment opportunities for all logistic officers. An officer can cross flow after they have at least four years in their primary specialty. They will normally cross flow into another logistics Air Force specialty code (AFSC) for a period of two years and then return to their original AFSC. Officers can cross flow at their current base as a permanent change of assignment (PCA) action or compete for

assignments for advertised positions on the Electronic Bulletin Board. Contact your assignment team (see below) for details.

Logistics Officer Assignment Branch Points of Contact

Branch Chief

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Transportation Officer Assignments

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Supply Officer Assignments

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Logistics Plans Officer Assignments

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Aircraft Maintenance Officer Assignments

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(Capt Ken Backes, HQ AFPC/DPASL, DSN 487-4024)

Civilian Career Management

Logistics Civilian Career Enhancement Program (LCCEP) On-Line

The Logistics Civilian Career Enhancement Program (LCCEP) is now providing information to its registrants via the establishment of a home page on the Internet. If you or someone you know has an LCCEP question, try the LCCEP home page first—you might find the answer plus answers to additional questions you may not have thought of yet.

The LCCEP home page can be accessed through the Air Force Personnel Center (AFPC) home page at "http://www.afpc.af.mil." On the AFPC home page, you will find Air Force Civilian Career Management which includes Air Force Civilian Career Programs (where LCCEP home page is located), the Air Force Civilian Training and Development Guide, Air Force Civilian Career Program Vacancies, Air Force Civilian Recruiting Programs, and Acquisition Certification Guidelines.

The LCCEP home page includes program registration procedures; locations, series, and grades of covered positions; Whole Person Score (WPS) information; Career Broadening locations and application requirements; PALACE ACQUIRE application procedures; and training and tuition assistance information. There is also a current listing of points of contact for personnel assigned to the program office. All information will be updated periodically.

We hope if you have a question about the program, you will look here first. If you do not see information that would be helpful to you as a registrant, let us know so we can add it to the LCCEP home page.

(Wallace Berkholtz, HQ AFPC/DPKCLO, DSN 497-4087)

(Continued from page 30)

Recommendations

Is there anything we can do in the Air Force to affect our support through the CIT process, now that it is underway? There is, and we should pay the utmost attention, since we are just entering Phase II of the program, which will run through September 1997. The Air Force CIT Office has obviously recognized problems that plagued Phase I of the transfer, and has made great strides in correcting what has been uncovered. Phase II of the program has been structured so similar problems will not reoccur. So, there *have been* lessons learned; funding levels have increased for AFMC and DLA, and the data transfer errors have been identified and corrected.

But that is not the end of the job at hand. At the retail and wholesale levels, we need to ensure demands are being properly and consistently recorded. We must accurately reflect the assets we are using to the wholesale level through these measures, but we also need to monitor the system, at both the retail and wholesale levels to ensure the data are getting through. Next, as much as is within Air Force leader's control, now that the funding posture is improving for AFMC and DLA, we need to ensure DLA continues to get adequate funding to support our requirements, including refilling empty pipelines and shelves. Finally, within the Air Force, we must better manage the assets that will eventually transfer in Phase II of CIT, but are still within our control. We recognize we have damaged our own support on items previously transferred, and probably those currently transferring, or transferring in the near future. We must work to support with equal fervor, and funding, those items that will later transfer and those that will not transfer at all.

These actions will not immediately improve DLA support of consumable items already transferred through Phase I of the CIT, but it is important we are aware of what is involved in this process. Now that we know how we hurt ourselves by transferring empty or limited pipelines, items with no or insufficient stock, and continuing to generate inaccurate data, it is important we maintain the progress the Air Force CIT Office has made through the rest of the Consumable Item Transfer.

Captain Deckett is currently serving as an Air Force Logistics Career Broadening Program Staff Officer at the San Antonio Air Logistics Center, Kelly Air Force Base, Texas. He would like to recognize the assistance and contributions of Colonel Eugene Leach, Lieutenant Colonel Thomas Huber, Major William Cameron, Mr Thomas Barton, Ms Catherine Cooper, and Ms Stephanie Lopez toward the development and publication of this work.

Training in the Age of Technology: The Hows, Whys, and Wherefores

Anthony S. Babiarz

We are inundated with changes to the current way that we do business. New methods, new procedures, and new techniques which are destined to "revolutionize our life" are coming onto the scene. Keeping up with the "new," let alone the "current," makes professional life difficult at times, near impossible at others. As a result, it is not only desirable, but also necessary to receive continual exposure to new material. One particular area which is continually bombarded with and by technological change is training. Training is a necessity, whether it be initial, refresher, or continuation. It is desired, needed, and required to accomplish a job in an efficient, effective manner. In addition, the techniques, presentation, and media have also changed a great deal. Computer-aided and computer-based presentations are no longer a novelty to be treated lightly. The machine, once thought of as a toy by some, can now be found in the office, the home, the classroom, and in the shop. We have come to depend upon computer hardware and select software to develop and present training to the neophyte and the journeyman. The ease of access to vast amounts of information provides greater exposure in a shortened period of time.

Introduction

The advent of new technology brings along with it the need for understanding. Not only do we have to understand the new technology, but we must also understand the best and most applicable methods for presentation. There are many ways to present the material, and, in general, most will work with varying degrees of success. The question is, however, which is the better method for presentation of information and which method will better prepare an individual to perform the task. Tasks, from the simple and routine to the complex and infrequent, must be done correctly the first time. Rework is expensive, inefficient, time-consuming and manpower intensive. It is necessary that workers know and understand what is expected of them and how to perform the task.

"One-on-one" can be an effective method for certain tasks. Information is relayed by word of mouth, visual presentation, and some written documentation. This is a "doable" method provided you have sufficient trainers and adequate time. The classroom or lecture method can convey a good deal of information in a short time to a small group. It combines lecture with visual aids and some written documentation. In each case, the written documentation is developed and directed at a specific reading comprehension level. We take for granted that everyone is able to read and comprehend at basically the same level. It is assumed that most people are "readily able to grasp" the written word in most documentation. The required reading comprehension level may or may not be compatible with the current level achieved by some trainees. This is becoming more of a problem as tasks become more technically oriented.

With the ready availability of off-the-shelf microcomputers and user-friendly software, great strides have been made in the world of the trainer and the trainee. Information deemed necessary for task accomplishment can be presented to the trainee in different formats. It can be developed using stationary or moving visual aids, written technical data, and even some verbal narration where necessary. The nature of this technology is such that it can be prepared and delivered in-house at a reasonable cost.

Background

In the past, training was accomplished either by some form of "one-on-one," on-the-job training, or the worker was turned loose with minimal verbal instruction. In either case, many workers were ill-prepared. It was felt by some employers that time was lost in orienting new employees. As such, they were given a task and expected to perform. In addition, it was felt that productivity was lost during "extended" training periods. As such, training was held to a minimum. In the mean time, it was necessary for the coworkers to absorb additional workloads until the new employee became productive. Depending upon the difficulty of the task and an individual's own initiative and personal skills, it could be some time before they were fully productive. While work forces were large and rework was "an accepted way of life," the employee was less than fully and properly trained. As a result, the cost of production rose to the point where some products and services were too expensive to survive. Those who were unable or unwilling to grasp the problem and institute corrective action lost.

To correct this problem, the pendulum must swing in the opposite direction. Competition requires doing the job correctly the first time. Productivity of the worker and quality of their work must be improved and maintained. It is paramount that each person fully understand their job and be properly trained. Once properly trained, the employee stands a better probability of producing a quality product acceptable to the customer.

How Do We Get There From Here?

There are many methods and means by which material can be presented to the trainee. But one thing that must be considered first and foremost is the trainee—their ability to learn and comprehend. According to an adult literacy survey in 1993, "90 million Americans over the age of 18 are functionally illiterate." This essentially means that, although they can read and write, they function below the level of the average eighth grade student. In most cases, these Americans are unable to properly fill out a job application, balance a checkbook, or follow simple directions. It is not meant to state that these individuals are ignorant, it does mean that "relying on written task descriptions to accomplish organizational objectives may not be the best way to get things done." (2:6)

How do we handle such a situation? It will take a good deal of work over a period of time. Is this situation something that can be handled and attained at a reasonable cost? The answer to that question is "yes;" it is an attainable goal. The writer and presenter of training material must consider the reading level of the intended audience. For example, a presentation on food handling and sanitation would be presented to a group of restaurant employees a little differently than to a group of forensic pathologists. Furthermore, not all tasks require the same level or degree of comprehension. The method of presentation, therefore, should take this into consideration.

Training should be presented in a manner and mode which is conducive to learning.

For the worker to succeed, he must be provided with the knowledge and understanding basic to the task at hand at the right time. The overall demand for quality requires that the worker know and understand the task requirements and have the ability to act and correct deficiencies as they occur. To accomplish this goal, it is necessary for the worker to have some understanding of the cause and effect relationship within the job and receive the required training as soon as possible. Once a requirement is identified and the employee selected, a method of training, best for the purpose, should be considered and developed. It should provide for the strengthening of a perceived weakness or provide knowledge in anticipation of a new requirement. The required training should then be provided to an employee as soon as possible. Quality training not provided in advance of the need could well result in a costly delay.

Initial training will establish the work foundation for an employee. As the employee is trained and the frustration level begins to decrease, productivity will tend to increase. With training taught correctly and up front, though it may appear time consuming, the worker will be enabled to provide a consistent quality product or service.

Training should be presented in a manner and mode which is conducive to learning. If a proper forum for application does not exist, it is possible, and even probable, the trainee will not retain the material. Reinforcement, along with adequate, meaningful practices will stimulate the individual mind, and is essential to proper assimilation and retention. Depending upon the type of task at hand and the chosen method of instruction, some classroom/oral presentation may be necessary to familiarize the trainee with the task, the operation, and procedures required. This could be followed by some additional classroom or individual learning through the use of visual aids to include slides, viewgraphs, movies, computer-based/computer-aided training, or a suitable combination of any or all of the above.

Training is not a luxury that is to be metered out to a select few. It is a continuous necessity that must be presented correctly the first time. Dependent upon the overall technology of the task, personal skills, and experience required, a period of hands-on, repetitive operations may suffice. As an alternative, since hands-on training may not be practical or available, other avenues should be considered. This will require an analysis of the task and training environment. Consideration should be given to the repetitive nature of the task, the associated hazards, skill or knowledge criticality, and the experience of the worker. Based on the task, the employee, and the ability to develop the particular methodology, consideration could be given to the use of properly selected, job-particular multimedia training.

The computer-based training could be presented in a classroom setting, a simulator-type situation, or, with advanced training scenarios, right on the job itself. The justification for this type of presentation revolves around exposing the worker to those activities which approximate real-life conditions, but allows for the commission of errors without penalty, injury, or reprisal. It allows the trainee to repeat, as often as desired, any or all sections of the material. It provides for the slow learner, the cautious learner, as well as the quick learner. It can be developed, based on the degree of competency and dollar budget available, to approximate the near-real working environment.

A review of some computer hardware and software available on the open market shows there are several systems which lend themselves to the most convenient use in the training arena. They are basically off-the-shelf microcomputers with user friendly software relatively easy to install and operate. Following the initial data input, it is possible to develop an orderly collection of screen images which can be interlinked in the development of a relatively inexpensive training tool. The cost, development, and upkeep of these computer-based training tools can be in the low to moderate price range, depending on the type of equipment, level of sophistication, and type of storage device used. The software examined can provide for initiation and indoctrination of the neophyte or an update or refresher for the journeyman. It can provide self-paced training which could be used without the need for a full-time instructor being present at all times. It has potential in the academic, industrial, and military arenas. (4)

Training is not a luxury that is to be metered out to a select few. It is a continuous necessity that must be presented correctly the first time.

A viable method of presentation, one which readily allows for update and change, is the use of a series of screens to present text and graphic material. The screens, developed with a "hypertext-type" format, can be interlinked and displayed in some form of sequential order. The trainee, once started on the material, could proceed through the screens, one after another, while being exposed to the material. Secondary screens could also be developed and activated by the student to provide additional material, an additional explanation, or a descriptive and labeled picture. This additional material could be activated by the student "clicking" on a built-in "button" with the mouse. This

button acts as a trigger which will allow the user to move from one screen to another, linking target information developed for the student. The number and depth of these secondary and reference screens would vary based on the desired depth of knowledge required, the need for additional explanatory material, and/or the need for cross-referencing of text and graphics. It is possible and quite beneficial to use secondary screens for "zoom" or "exploded" views of graphic technical reference information such as a part number, stock number, or catalog and storeroom location. These secondary screens can be used as sources of information to explain what does or should happen under specific conditions. The information could include the theory of operation, specialized or unique operational requirements, as well as peculiar support equipment or test equipment requirements under specified conditions. (3)

Before embarking on a mission to develop interactive, multimedia, computer-based training, consider the goal to be achieved.

To ensure the student has grasped the material, there is a capability to insert a single or series of test screens that require passage before being allowed to continue. The test can be "true" or "false" or multiple choice-type questions. Upon selecting the right answer to the question, the trainee receives some form of positive reinforcement and feedback. This is important to the welfare and morale of the trainee. If the question is answered incorrectly, the trainee will receive counseling that the answer is incorrect, provided with a brief explanation as to why the answer is incorrect, and returned to the test question for another try. If, on the second attempt, the question is answered incorrectly, the trainee can be provided with a reference to the correct answer along with a recommendation for additional review before continuing with the self-test. It is possible to maintain a record of the trainees' results of section reviews and end of course tests. The intent is to determine who may require additional assistance to understand the required material. The number and depth of testing will be dependent upon the type of material, the knowledge level required, and understanding desired. (1)

Training material is not limited to flat screen, two-dimensional images. It is possible to develop material which will interface and interact with 12-inch laser discs, video cassette playback systems, compact discs, and removable hard drives. These additives provide for the inclusion of simple and detailed images, sound, motion, "zoom," and "exploded" images. The sound and motion can be keyed into a static image activated by a touch-sensitive monitor screen or a "button" activated by a mouse.

Before embarking on a mission to develop interactive, multimedia, computer-based training, consider the goal to be achieved. The goal is to train personnel to perform selected tasks. Examine the degree of knowledge required—general, specific, or in-depth. It will also be necessary to determine if the training is a "one-time shot," an occasional occurrence, or for a repetitive task. These pertinent factors will not only influence the possible training medium or method of presentation, but they will also influence the cost and capability required to develop a finished product. A good deal of the program design, development, and production preparation can be accomplished in-house. It is, however, necessary to determine if this is the most effective and efficient route to follow. To do the work in-house, it will be necessary to have the technical competence and subject matter expertise needed to perform the process or procedure. The equipment necessary for production and playback will vary with the depth of production desired. The requirements can range from something as simple as a laptop or microcomputer to a full range of top-of-the-line Pentiums (in today's reference) with 4X CD-ROMs, graphics and video cards, digitizers, sound recording equipment and midi cards, along with scanners for one form of text input. On the software side of the house, there are a number of user friendly packages that readily lend themselves to production and development. As an example, a disk operating system (DOS) version of *Guide* was used to develop an easy to use, quick reference version of the Military Standard Requisition and Issue Procedure (MILSTRIP). The package was developed to provide ready access to the text and forms in color, references, acronyms, and definitions from any place in the package. Self-test objective measurements are strategically located throughout the MILSTRIP package. They are linked to the text to provide documentation and reference material access.

Since the release of the early DOS version of *Guide*, the software has come a long way. What was thought to be "easy" before has now become better, faster, and more compliant. Products are now available in Windows format that will allow for automatic production of interactive electronic publications. The software allows for display of tables and images in line with text or in separate windows with pan and zoom control. It also supports full integration of multimedia objects like sound, video, and animation, as well as dynamic links to other applications. Another piece of software in the *Guide* family brings oversized images to on-line documentation. No matter what the size of the computer screen, nearly any size image can be displayed. In one screen, the full object can be displayed. With a specifically located "button" or "hotspot," the image can be "exploded" to reveal a predetermined level of disassembly and view. Such a display is ideal for wiring and piping diagrams, flowcharts, and schematics. (4)

What is the purpose of this advanced technology? It is a relatively simple way to present complex material to trainees. What can it do that others may not be able to do? It is possible to develop training packages which can satisfy numerous levels of knowledge, experience, and reading comprehension all within the same package. By "layering" technical data, it is possible to draw out information, prompt the trainee to think through a problem or situation, and act. Using linked screens with primary and secondary backup information, it is possible to develop basic maintenance diagnostic text material and graphics to approximate a real-work task. Developed around actual diagnostic trees, it is possible to design troubleshooting and repair scenarios for the novice, the cross trainee, or the journeyman. The version for the novice or cross trainee could be structured to provide only a single specific path from beginning to end. The reason for this structure

is to assist the individual to develop a "troubleshooting methodology" and a systematic approach to problem solution. As experience and expertise are developed, this same package, following a slightly different path, could allow the journeyman to chart a nonstructured path from beginning to end. At the completion of that task, the action taken could then be reviewed and analyzed and recommendations provided when and where necessary. The type, amount, and depth of material presented at any one time should be appropriate for the size and detail of the lesson and the intended result. If too much information is provided too quickly, the trainee could become confused, disillusioned, and negatively motivated. If too little information is provided or if the exercise is not challenging enough, the trainee could become bored, overconfident, and easily make errors. At the same time, the trainee must be cognizant of what is expected during the training classes and upon completion of the training.

To do a job correctly, workers must know what is expected of them, what they must do, and how to do it.

Serious consideration should be given to the development and application of computer-based training for a number of reasons. Computer-based training, if properly developed, can and does present a quality picture of the task at hand. It allows the trainee to proceed at a pace commensurate with one's ability to absorb and assimilate the material. As a user-driven methodology, it provides a good deal of flexibility allowing the individual to review as often as necessary before moving to the next bit of material. Computer-based training lends itself to independent study. The material could be made available at any time in a predetermined location compatible for learning. It negates the requirement for a full-time instructor to be present at all times.

Computer-based training, as opposed to lecture presentation, is based on different human faculties. Hearing is a physical process, while listening is an intellectual process requiring a great deal of discipline. We speak at approximately 125 words a minute and listen at about 550 to 600 words a minute. The difference in time allows the mind to wander and get off track. Studies show a listener will remember 50% of what they hear for about 48 hours, only 25% after 48 hours, down to 10% after 10 days. On the other hand, demonstration-type material, to include computer-based material, is retained for up to 10 days at the 65% level. (8) Visual reinforcement, reviewed at an individual pace, provides greater retention and a reduction of fear, anxiety, and tension. It provides for learning to be an enjoyable experience rather than a traumatic one.

Conclusion

Education and training are of great concern. To do a job correctly, workers must know what is expected of them, what they must do, and how to do it. It is necessary for the employer to ensure the workers are prepared to function in an appropriate manner. Proper initial training followed by upgrade or refresher training as necessary, will cost time and money up front, but this cost is much lower than the extended cost to rework and/or suffer the loss of customers. It is the role of the company to stay in business, create a consistency of purpose, and strive for continued improvement. Companies need to adopt the philosophy to produce quality products and overturn the tolerance for poor workmanship. Success is built on the knowledge and understanding of what is correct. The work force and its management must continuously be kept abreast of changes as they occur and train accordingly. (3)

References

1. Babiarz, Anthony S. "Computer-Based Diagnostics and Training System — Logistics Technology for the 21st Century," *Proceedings of the 23rd Annual International Logistics Symposium*, Aug 88.
2. Callahan, Anita, and Paul R. McCright. "Literacy and Its Effects on Job Design," *Industrial Management*, Vol. 37, No. 1, Jan/Feb 95.
3. Deming, W. Edwards. *Out of Crisis*, Cambridge: The MIT Press, 1986.
4. Duncan, Mark. "Critical Success Factors for the Training Program," *Computer World*, Vol. XXIII, No. 48, p. 109, 27 Nov 89.
5. Interview with Robert J. Faust, Business Development Manager, InfoAccess Inc., Canton, Michigan, 14 Mar 95.
6. Hendricks, Mark. "It's Not Just Academic," *Small Business Reports*, Vol. 19, No. 5, pp. 23-31, May 94.
7. Hogarty, Donna Brown. "A Little Education Goes A Long Way," *Small Business Reports*, Vol. 18, No. 12, pp. 47-55, Dec 93.
8. Keyes, Jessica. "Teaching Presentation Skills," *Info World*, Vol. XXIV, No. 33, 13 Aug 90.

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Most Significant Article Award

The Editorial Advisory Board has selected "Systematic Readiness Engineering Analysis: Converting Modern Mythology Into Future Reality" by William Jones, Jr. and Deborah S. Motz, as the most significant article in the Winter 1996 issue of the *Air Force Journal of Logistics*.

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